# Crooked Lake Engineering Feasibility Study

Steuben County, Indiana

April 29, 2005

Prepared for:

**Crooked Lake Association**
c/o Keith Hoskins
P.O. Box 573
Angola, Indiana 46703

Prepared by:

c/o Sara Peel
708 Roosevelt Road
Walkerton, Indiana 46574
574-586-3400

# CROOKED LAKE ENGINEERING FEASIBILIY STUDY
# STEUBEN COUNTY, INDIANA

## EXECUTIVE SUMMARY

The Crooked Lake Association (CLA) received an Indiana Department of Natural Resources (IDNR) Lake and River Enhancement (LARE) grant to complete an engineering feasibility study on lake improvement projects. The engineering feasibility study is based on work completed during the Crooked Lake Monitoring Study (JFNew, 2003). The goal of the feasibility study was to analyze potential project sites where sources of pollution may exist, suggest projects that may address pollution, and examine the feasibility of project design and construction. To be deemed feasible, a project needs to be acceptable to property owners, receive regulatory agency support, be physically constructible, and be environmentally and socially justifiable.

This study examined the feasibility of five projects within the Crooked Lake Watershed. The projects are: streambank stabilization of Carpenter Drain at the Steuben County 4-H Park, stormwater treatment along Palfreyman Drain at the Steuben County Highway Department facility, stormwater treatment at the Steuben County 4-H Park, stream reconstruction for the entirety of Palfreyman Drain, and wetland restoration at eight potential sites throughout the watershed. The Carpenter Drain streambank stabilization project includes soil-encapsulated lift installation along approximately 200 lineal feet of streambank and has an estimated cost of $27,750. The IDNR LARE Program provided funding for this project in 2004/2005. The stormwater treatment project located along Palfreyman Drain at the Steuben County Highway Department facility consists of infiltration trench, vegetated swale, and riprap installation and has an estimated cost of $38,610. The stormwater treatment project located at the Steuben County 4-H Park includes the installation of rain gardens and drainage swales. This project has an estimated cost of approximately $60,370. The stream reconstruction for the entirety of Palfreyman Drain has an estimated cost of $45,000 for design services only. A feasible wetland restoration project could not be identified; therefore, cost estimates were not generated for the wetland restoration projects. Funding for each of the above mentioned projects could be obtained from the IDNR LARE program or the Great Lakes Commission Great Lakes Sediment Control program.

It is recommended that the Crooked Lake Association complete design and construction work on the Carpenter Drain streambank stabilization project in 2005. The CLA should apply for a LARE grant for the design of the proposed stormwater treatment project at the 4-H Park and a Great Lakes Commission sediment control grant for construction of this project. Additionally, the CLA should apply for a LARE grant for the redesign of Palfreyman Drain in 2005.

## ACKNOWLEDGMENTS

The Indiana Department of Natural Resources Division of Soil Conservation Lake and River Enhancement Program and the Crooked Lake Association funded this feasibility study. JFNew documented available historical information, assessed project feasibility and environmental impact, and developed opinions of probable cost for the feasible projects identified during the 2003 Crooked Lake Monitoring Study. Keith Hoskins of the Crooked Lake Association provided initiative and assistance in getting this study completed. Special thanks are due to the Steuben County Commissioners for their assistance in identifying feasible projects. The Steuben County assessor's office provided property owner information for the project areas. Thanks to the Crooked Lake Association members for support. Contributors to this project include Sara Peel, Wayne Stanger, John Richardson, and Joe Exl with JFNew.

## TABLE OF CONTENTS

**PAGE**



## LIST OF TABLES

**PAGE**

## LIST OF FIGURES

**PAGE**



## LIST OF APPENDICES

# CROOKED LAKE ENGINEERING FEASIBILIY STUDY
# STEUBEN COUNTY, INDIANA

## 1.0 INTRODUCTION

### 1.1 Background

Over the past few years, Crooked Lake property owners and lake users have noted declining water quality within Crooked Lake and its watershed streams. Noted in-lake issues and lake water quality concerns include: an increase in sediment bar formation, the loss of plant beds in shallow areas, and a decline in water clarity. JFNew conducted water quality sampling within the tributaries to Crooked Lake and watershed surveys to identify potential water quality improvement projects in the spring of 2003. Results from these assessments can be found in the Crooked Lake Monitoring Report (JFNew, 2003). According to the study, water quality in the lake's tributaries generally meets Indiana state standards or Ohio EPA or U.S. Environmental Protection Agency suggested criteria. The study recommended addressing watershed-level issues before attempting in-lake treatment. These watershed-level issues included: bank and channel erosion along Carpenter and Palfreyman Drains, wetland restoration within the Carpenter and Palfreyman Drains subwatersheds, stormwater quality and quantity entering the lake from storm drains within the City of Angola and immediately adjacent to Crooked Lake, and roadside trash and associated pollutant introduction from portions of the drains that parallel county roads. In 2003, the Crooked Lake Association (CLA) received a grant from the Indiana Department of Natural Resources (IDNR) Lake and River Enhancement (LARE) Program to conduct an engineering feasibility study. The purpose of the current study is to determine design and construction feasibility of recommended projects in the Crooked Lake Watershed.

### 1.2 Scope of Study

The geographic scope of the study includes Crooked Lake and its 7,512-acre (3,040-ha) watershed in Steuben County. This feasibility study targeted the entirety of Crooked Lake's watershed but focused mainly on the Carpenter and Palfreyman Drain subwatershed areas for project implementation. JFNew conducted field surveys in the Carpenter and Palfreyman Drain subwatersheds in order to identify locations where projects could be implemented that would result in water quality improvements in the lake and its tributaries. Surveys included a lake and watershed driving tour, visual inspection and mapping of potential project sites, and several public and private meetings with landowners and stakeholders. Based on the surveys' findings, the following projects (refer to Figure 1) are included in this engineering feasibility study:

1. Bank stabilization along Carpenter Drain, Steuben County 4-H Park.
2. Stormwater treatment along Palfreyman Drain, Steuben County Highway Department facility, County Road 200 North and County Road 200 West.
3. Stormwater treatment, Steuben County 4-H Park.
4. Stream reconstruction along Palfreyman Drain from its headwaters to its intersection with County Road 200 North.
5. Wetland restoration, Carpenter Drain, Palfreyman Drain, and Loon Lake Tributary subwatersheds.

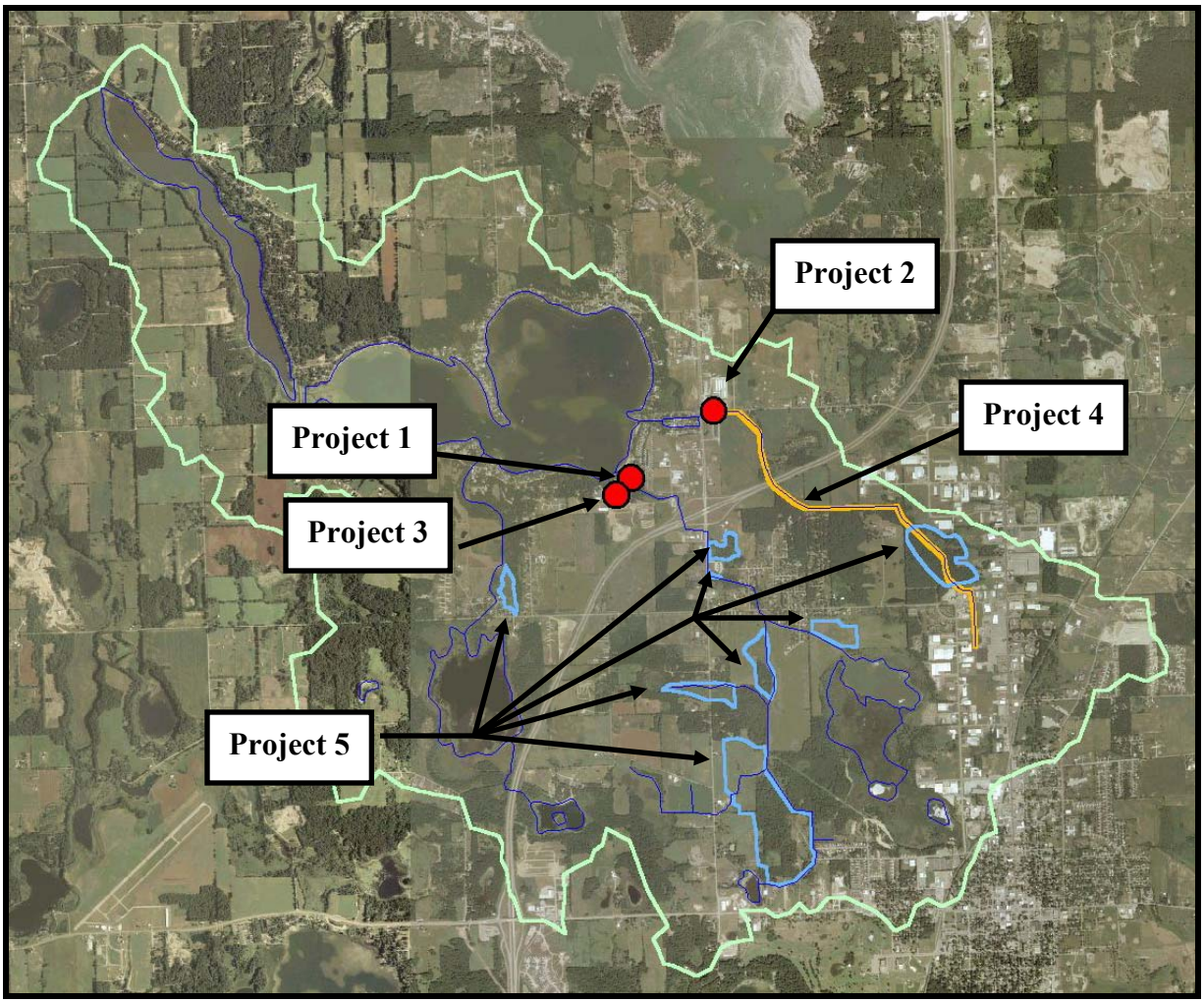


**Figure 1. Engineering feasibility study proposed project locations.**

### 1.3 Goals and Objectives

The goal of this study was to identify feasible projects that could be designed and implemented within a reasonable time frame. A project was deemed feasible if it could physically be constructed, was acceptable to landowners, was economically and ecologically justifiable, and could receive regulatory approval. The feasibility study attempted to ensure project success by investigating all avenues that could potentially cause project failure.

## 2.0 DESCRIPTION OF THE STUDY AREA

### 2.1 Location

The Crooked Lake Watershed (14-digit hydrologic unit code 04050001090040) encompasses 7,512 acres (3,040 ha) in central Steuben County, Indiana (Figures 2 and 3). The watershed is part of the St. Joseph River Basin, which drains water to Lake Michigan. Three drainages, Carpenter Drain, Palfreyman Drain, and the Loon Lake Tributary, transport runoff water from the watershed to Crooked Lake (Figure 4). Carpenter Drain is the longest of the three tributaries and possesses the largest subwatershed. Carpenter Drain originates in the northwestern portion of

the City of Angola and flows north and west draining 1,987 acres (804 ha). Palfreyman Drain originates in the northwestern portion of the City of Angola and flows northwest to Crooked Lake. The Palfreyman Drain subwatershed covers a total of 1,765 acres (714 ha). The Loon Lake Tributary drains 1,021 acres (413 ha) immediately south of Crooked Lake. The remaining 2,739 acres (1,108 ha) of land drains directly to Crooked Lake. Water drains from the northwest corner of the third basin of Crooked Lake through an unnamed tributary to Lake Gage. After leaving Lake Gage, Lime Lake, and Tamarack Lake, the tributary combines with Crooked Creek east of Orland. Crooked Creek in turn flows into Fawn River, then into Pigeon Creek, before entering the St. Joseph River near Constantine, Michigan.

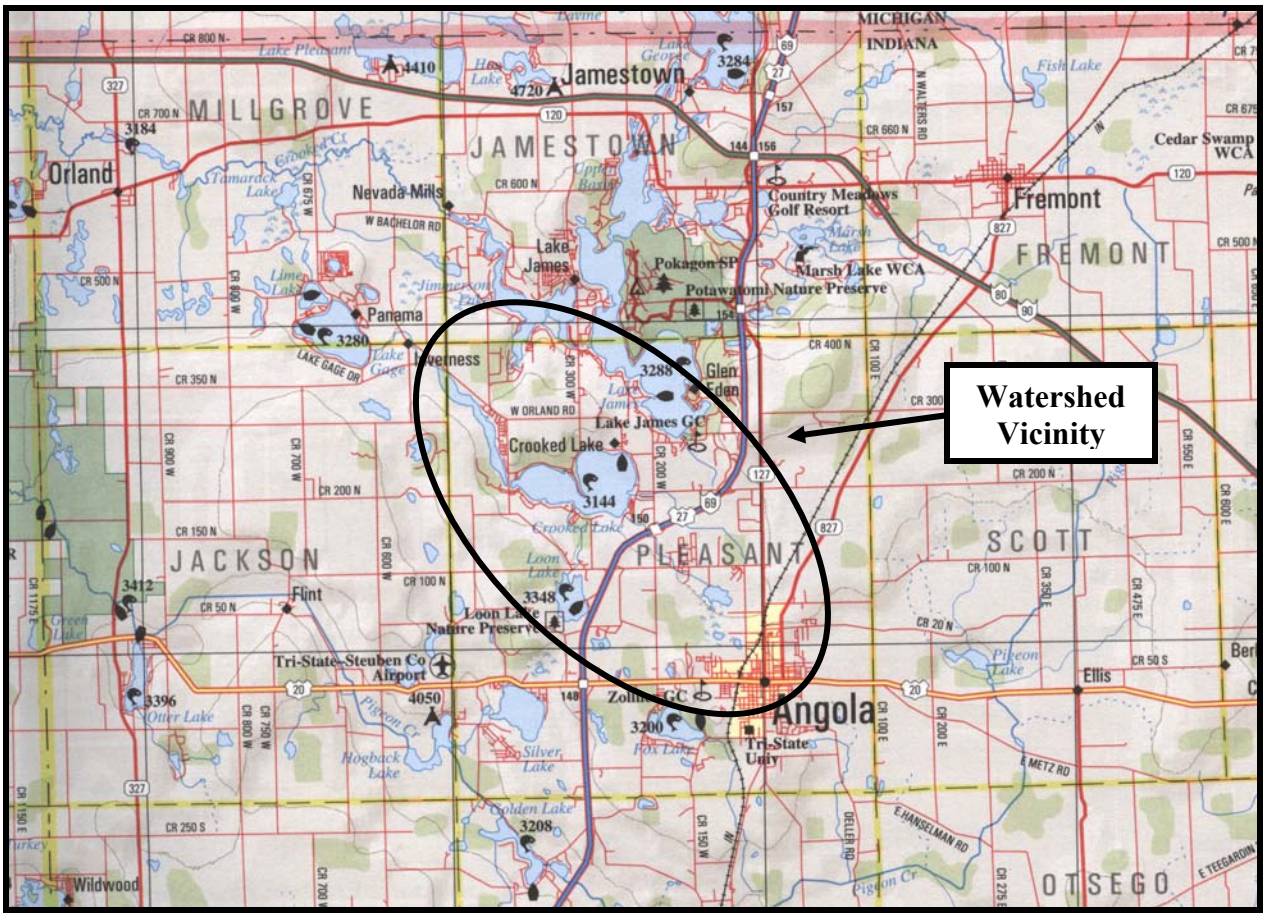

**Figure 2. General project location.** Source: DeLorme, 1998.

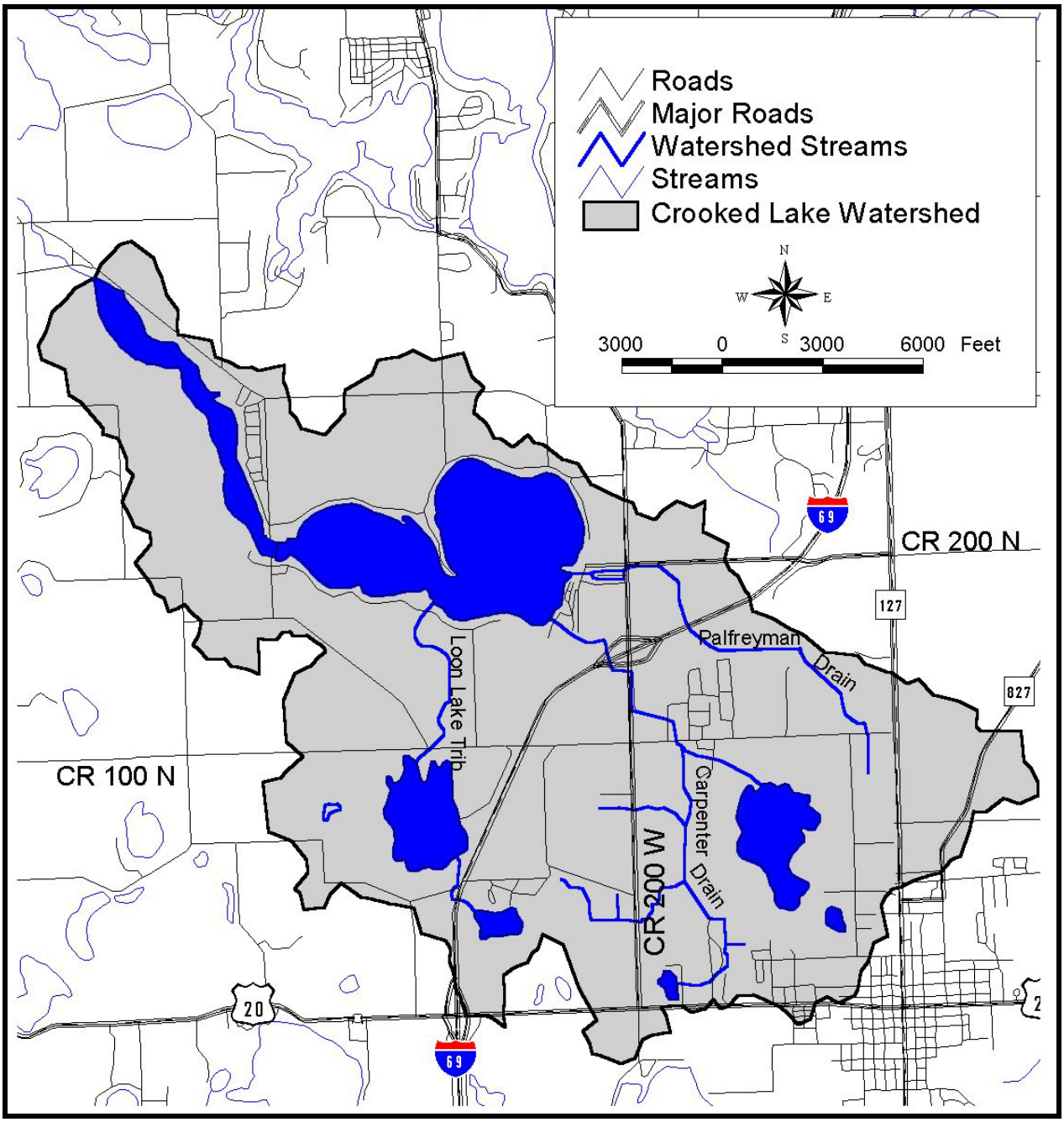


**Figure 3. Crooked Lake Watershed.**

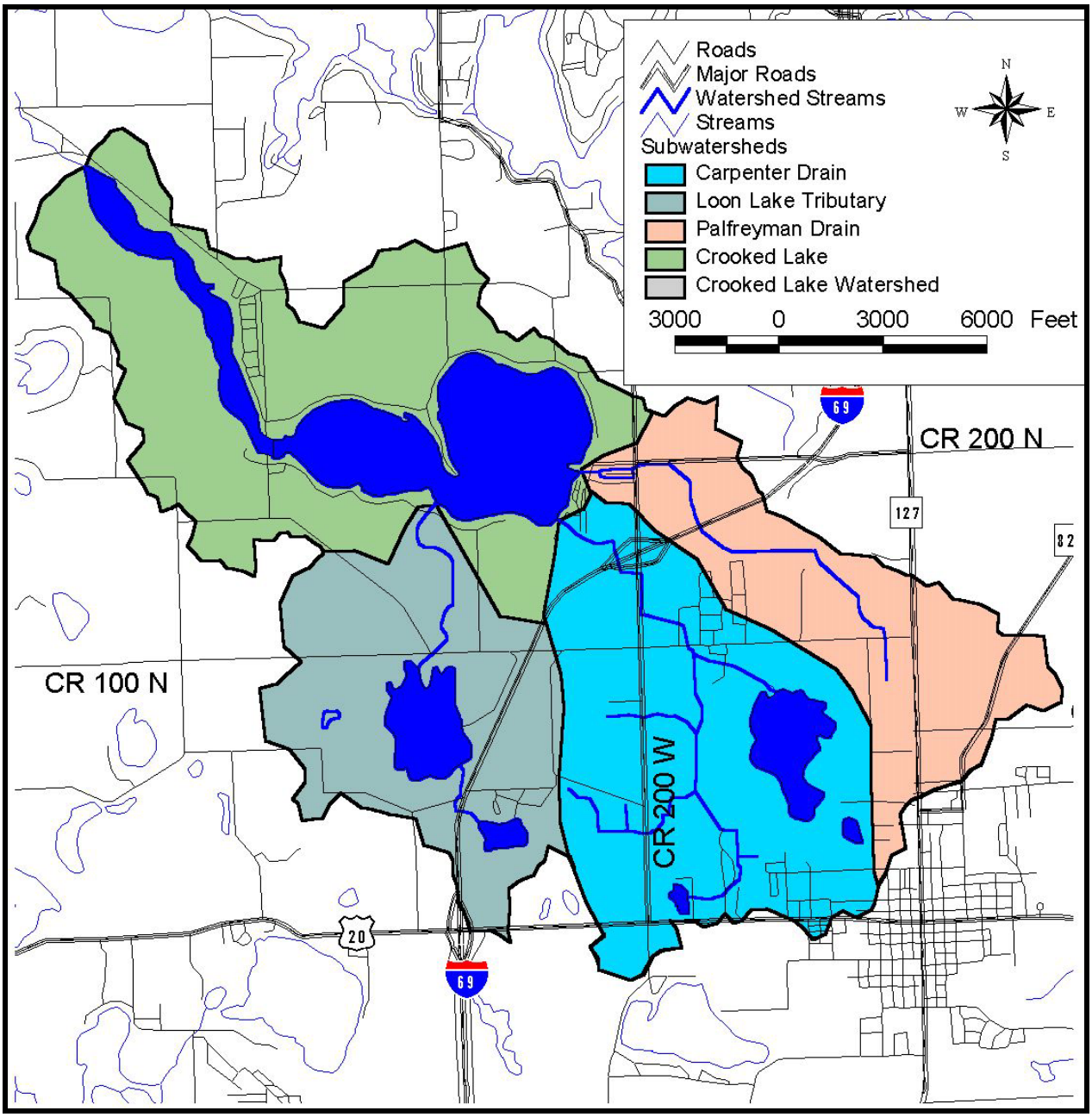


**Figure 4. Crooked Lake subwatersheds.**

## 2.2 Geologic History and Topography

Crooked Lake and its watershed formed during the most recent glacial retreat of the Pleistocene era. The advance and retreat of the Saginaw Lobe of a late Wisconsin Age glacier, as well as the deposits left by the lobe, shaped much of the landscape found in northeastern Indiana (Homoya et al., 1985). The Saginaw Lobe's retreat left a broad, flat to rolling glaciated plain, which has been classified as the Northern Indiana Till Plain Ecoregion (Omernik and Gallant, 1988). Glacial fill and outwash, sandy gravelly beach ridges, flat belts of morainal hills, and bog kettle depressions characterize this ecoregion (Simon, 1997). The topography of the Crooked Lake Watershed is typical of much of Steuben County and reflects the geologic history described

above. Land to the west of Crooked Lake exhibits a gently rolling topography. Relief changes from approximately 1050 feet above mean sea level at the highest point in the watershed to approximately 988 feet at the lake. Land to the east of the lake is flatter than land to the west of the lake with large wetland expanses draining through Carpenter Drain to the lake.

### 2.3 Land Use

The Crooked Lake Watershed lies within the Northern Lakes Natural Area (Homoya et al., 1985). Natural communities found in this region prior to European settlement included bogs, fens, marshes, prairies, sedge meadows, swamps, seep springs, lakes, and deciduous forests. Like much of the landscape in Steuben County, a large portion of the Crooked Lake Watershed was converted to agricultural land uses. Today, about 54% of the watershed is utilized for agricultural purposes including row crop and pasture (Table 1; Figure 5). Corn and soybeans are the major crops grown on this land. An additional land use change has been residential development of much of the lake's shoreline and urban development along the Interstate-69 corridor and around the northern and northwestern edges of the City of Angola. Consequently, residential and commercial land use currently composes 7.6% of the total watershed acreage. Forests, wetlands, and open water account for approximately 38% of the total watershed.

**Table 1. Land use in the Crooked Lake Watershed.**

| Land Use | Acreage | Percentage |
|---|---|---|
| Row Crops | 2,972.3 | 39.6% |
| Deciduous Forest | 1,278.2 | 17.0% |
| Pasture/Hay | 1,063.4 | 14.2% |
| Open Water | 1,006.2 | 13.4% |
| High Intensity Commercial/Industrial/Transport | 314.3 | 4.2% |
| Emergent Herbaceous Wetlands | 306.4 | 4.1% |
| Woody Wetlands | 296.7 | 3.9% |
| Low Intensity Residential | 225.1 | 3.0% |
| High Intensity Residential | 32.5 | 0.4% |
| Evergreen Forest | 12.9 | 0.2% |
| Mixed Forest | 2.6 | <0.1% |
| Urban Parkland | 0.8 | <0.1% |
| **TOTAL** | **7,511.4** | **100.0%** |

Source: USGS/EROS Indiana Land Cover Data Set, Version 98-12.

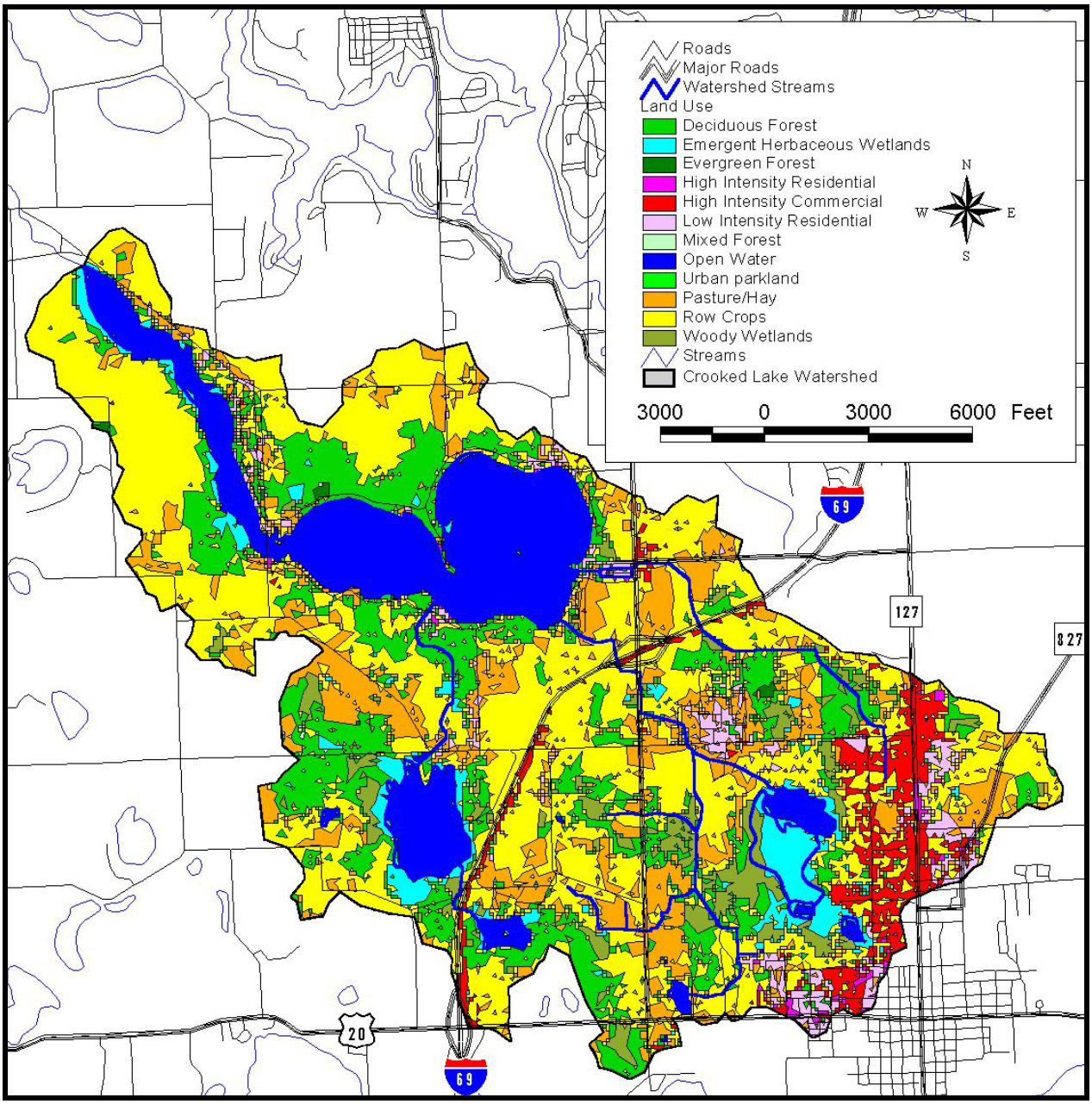


**Figure 5. Land use in the Crooked Lake Watershed.**

## 2.4 Soils

The soil types found in the Crooked Lake Watershed are a product of the original parent materials deposited by the glaciers that traversed the area 12,000 to 15,000 years ago. The Kosciusko-Ormas-Boyer soil association covers the majority of the Crooked Lake Watershed. Soils that directly border the first and second basins of Crooked Lake and cover much of the Palfreyman Drain and Carpenter Drain subwatersheds are part of the Kosciusko-Ormas-Boyer soil association. This association is primarily composed of well-drained sand and gravel soils that formed on outwash plains and moraines. The Glynwood-Morley-Blount soil association consists of well-drained to poorly drained, silty soils. This association covers much of the southeastern portion of the watershed within the City of Angola. The Riddles-Miami-Brookston

soil association borders the third basin of Crooked Lake and occupies the Loon Lake Tributary subwatershed. Soils of the Riddles-Miami-Brookston soil association are poorly drained, loamy soils which formed on till plains (Farmer, 1981).

### 2.5 Prior Studies

Table 2 lists prior studies conducted in the Crooked Lake Watershed. Most studies conducted in the area have been focused on documenting existing water quality or fishery conditions within the lake. More recent work focused on the lake's plant community and on watershed and water quality improvement projects.

**Table 2. Prior studies conducted in the Crooked Lake Watershed.**

| Year | Entity | Topic | Study |
|---|---|---|---|
| 1967 | IDNR, DFW | Fisheries | Lake Survey Report, Crooked Lake |
| 1973-1977 | SCLC/SCHD | Water Quality | Stream Water Quality Monitoring Program |
| 1973 | IDNR, DFW | Fisheries | Lake Survey Report, Crooked Lake |
| 1975 | USEPA | Water Quality | National Eutrophication Survey: Crooked Lake, Steuben County, Indiana, Working Paper No. 325 |
| 1979 | IDNR, DFW | Fisheries | Lake Survey Report, Crooked Lake |
| 1980 | Purdue | Water Quality | Trophic Status of Fifteen Indiana Lakes in 1977 |
| 1981 | USEPA | Wastewater Treatment | Environmental Impact Statement: Alternative Waste Treatment Systems for Rural Lake Projects, Case Study Number 4, Steuben Lakes Regional Waste District, Steuben County, Indiana |
| 1986 | IDEM | Water Quality | Indiana Lake Classification System and Management Plan |
| 1987 | IDNR, DFW | Fisheries | Lake Survey Report, Crooked Lake |
| 1991 | IDNR, DSC/ WWHA | Watershed Management | Crooked Lake: Watersheds of the Carpenter and Palfreyman Ditches Feasibility Study |
| 1992 | IDEM, CLP | Water Quality | Indiana Clean Lakes Assessment |
| 1996-2002 | IDEM, CLP/ CLA | Water Quality | Indiana Clean Lakes Volunteer Monitoring Program |
| 1997 | IDEM, CLP | Water Quality | Indiana Clean Lakes Assessment |
| 1998 | IDNR, DFW | Fisheries | Largemouth Bass Investigation |
| 1998 | IDNR, DSC | Water Quality | Wetland Construction, Palfreyman Drain |
| 1999 | IDNR, DSC/ CLA | Plant Community | Whole-Lake Experimental Plant Community Control |
| 2001 | IDNR, DFW | Fisheries | Assessment of Advanced Walleye Fingerling Stockings at Northern Indiana Lakes |
| 2001 | IDNR, DFW | Fisheries | Crooked Lake Fish Management Report |
| 2002 | IDEM, CLP | Water Quality | Indiana Clean Lakes Assessment |
| 2003 | CLA/JFNew | Watershed Management | Crooked Lake Monitoring Study |
| 2004 | IDNR/DSC, JFNew | Watershed Management | Crooked Lake Engineering Feasibility Study |

CLA=Crooked Lake Association
CLP=Clean Lakes Program
DFW=Division of Fish and Wildlife
DSC=Division of Soil Conservation
IDNR=Indiana Department of Natural Resources
IDEM=Indiana Department of Environmental Management
JFNew=J.F. New and Associates
Purdue=Purdue University
SCHD=Steuben County Health Department
SCLC=Steuben County Lakes Council
USEPA=U.S. Environmental Protection Agency
WWHA=William W. Hill and Associates, Inc.

# 3.0 PROJECT REVIEW

## 3.1 Bank stabilization along Carpenter Drain at the Steuben County Park

### 3.1.1 Site Description and Alternatives

The Carpenter Drain bank stabilization project area is located on the southeast side of Crooked Lake off of Lane 101 Crooked Lake (Figure 1). The Carpenter Drain subwatershed drains 1,987 acres (804 ha or 3.1 square miles) from its headwaters to its mouth. The drain originates within the City of Angola industrial park then flows through predominantly agricultural and residential land. The watershed exhibits greater topographic relief in the stream's headwaters but is flatter near the stream's mouth. Overall, the stream falls from nearly 1,050 feet above mean sea level to approximately 988 feet at its confluence with Crooked Lake. Carpenter Drain is a legal drain from its headwaters to its intersection with Interstate-69. This means that the Steuben County Surveyor's office can collect ditch assessment fees along this portion of the drain in order to maintain proper drainage. However, the portion of Carpenter Drain in which this project is located is not a legal drain; therefore, it is not under the jurisdiction of the Steuben County Surveyor.

The reach assessed during this feasibility study included approximately 1,100 lineal feet of the mainstem of Carpenter Drain located entirely within the Steuben County 4-H Park. Steuben County owns and maintains this property. Soils nearest the creek are loamy sands and muck bordered by sandy loams. Forested land and forested wetland border Carpenter Drain along the project site. No change in this land use is expected in the future. Musclewood, black cherry, sycamore, red oak, cottonwood, and American elm vegetate the uplands adjacent to the stream.

Carpenter Drain is hydrologically connected to its floodplain along the portion of stream included in this project site. However, the streambank is eroding in multiple places along the project site. (Appendix A contains representative photos of the project site.) Additionally, large pieces of debris (i.e., old culvert pipes, etcetera) located within the stream have deflected the water's force toward the banks scouring the bank in several places. This portion of the creek does not appear to have been dredged or straightened in the past. Although the streambanks are not uniformly steep throughout the entire reach, in places of heavy erosion, they average 3-4 feet in height.

Stabilization of eroded streambanks is recommended to reduce sediment and sediment-attached pollutant delivery to Crooked Lake. Alternatives for bank stabilization and restoration in the surveyed reaches included: riprap, other forms of hard armor such as sheet piling, or bioengineering techniques to establish natural plant materials. Due to a desire to maintain the stream's aesthetic appearance and protect its natural habitat, bioengineering techniques employing the use of native plant materials were selected for the Carpenter Drain bank stabilization projects.

### 3.1.2 Easement and Land Availability Determination

Prior to accessing the Carpenter Drain project site for field inspection and project design purposes, landowner permission was obtained from the Steuben County Commissioners. The Steuben County Commissioners reviewed the proposed bank stabilization techniques at their

January 2004 meeting and approved the conceptual work. Presently, the Commissioners have no definite plans for this portion of Carpenter Drain or its floodplain, so the land is available for design and construction of the proposed project. The Steuben County Commissioners have signed a letter supporting the project as conceptually designed (Appendix B).

### 3.1.3 Preliminary Design and Conceptual Drawings

Streambank stabilization along Carpenter Drain will consist of the installation of soil-encapsulated lifts and the removal of remnant debris in three locations along the 1,100-foot reach (Figure 6). The first project area (Site 1) is located where an old road crossing and remnant culvert created a cut bank approximately 4 feet high and 30 feet long on the north bank and a cut 3.5 feet high and 20 feet long along the south streambank. The culvert will be removed from the stream and the streambanks reshaped prior to installing soil-encapsulated lifts. A total of 60 lineal feet of streambank stabilization will occur at this site. The second project area (Site 2) occurs where a sharp bend in the stream directs flow into the streambank causing sediment and sediment-attached pollutants to be eroded from the streambank. Approximately 50 lineal feet of soil-encapsulated lifts will be installed along the north bank at this project area. A woody debris jam facilitated streambank erosion along approximately 90 lineal feet at the third project area (Site 3). The log debris jam will be removed, banks reshaped, and soil-encapsulated lifts installed along both the north and south streambanks of this portion of the project site. The total length of bank receiving treatment is approximately 200 lineal feet.


**Figure 6. Carpenter Drain bank stabilization project plan view.**

Soil-encapsulated lift structures are constructed by installing a toe of large diameter fieldstone and wrapping coir fabric around a soil lift that is keyed into the bank (Figure 7). Grasses and woody vegetation are then used to stabilize the lift. Bare-root shrubs will be incorporated into the lift to establish long-term scour protection, hide the lift fabric, and provide lateral stability. The fabric typically lasts for up to 10 years, allowing enough time to establish permanent vegetative cover for erosion control.

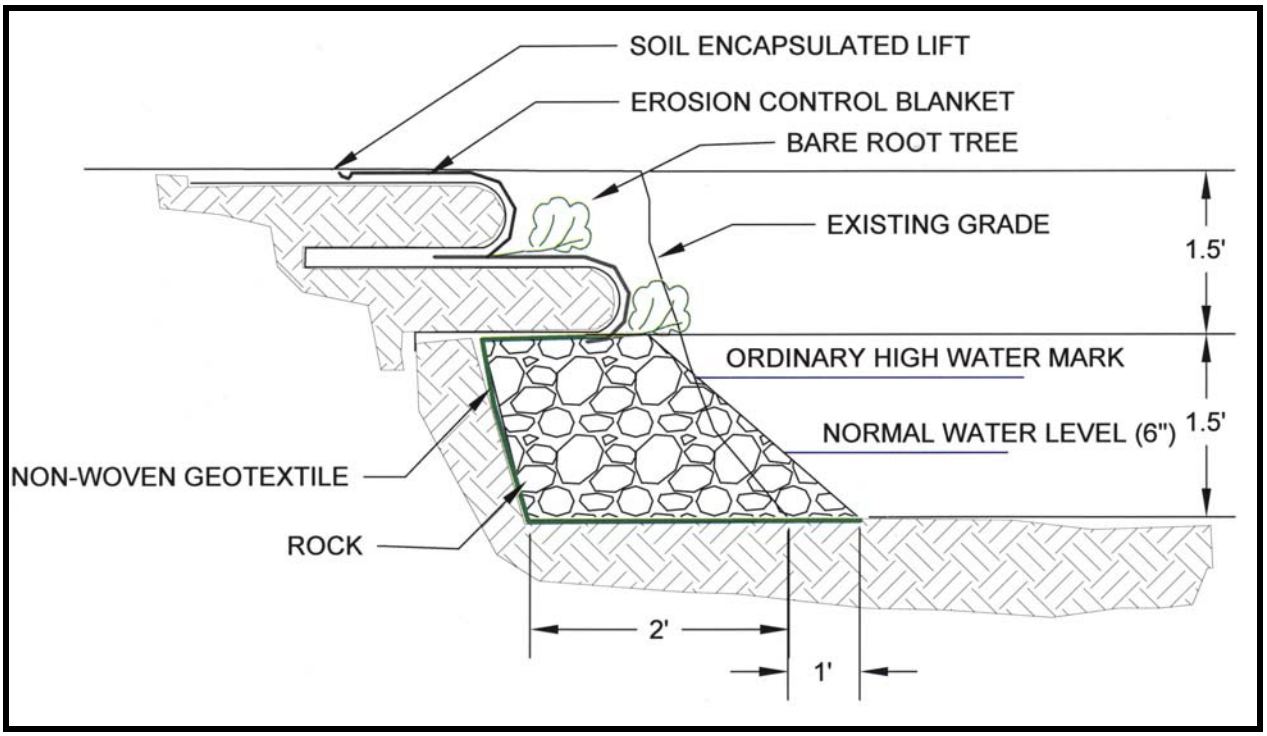


**Figure 7. Soil encapsulated lift conceptual diagram.**

### 3.1.4 Permit Requirements

Projects associated with this portion of Carpenter Drain will not require a permit from the Steuben County Drainage Board, as it is not a legal drain. An Indiana Department of Natural Resources (IDNR) construction within a floodway permit is necessary for this project since the project will occur within the floodway and the drainage area upstream of the project location is greater than one square mile. A Section 401 Water Quality Certification from the Indiana Department of Environmental Management (IDEM) and a Section 404 Permit from the US Army Corps of Engineers (Corps) are both required because the stream is considered a "waters of the United States". Permit applications were submitted to the IDEM, IDNR, and Corps and were obtained from the three agencies. Copies of the permits are included in Appendix C.

### 3.1.5 Wetland Functional Assessment

The general locations and extents of two wetlands were mapped during a field survey conducted on January 7, 2004. Figure 6 shows the approximate locations of these wetland areas. Wetland A is located along and north of the northern streambank of Carpenter Drain. Wetland B is located adjacent to the southern bank of Carpenter Drain. Dogwood (*Cornus* species), cottonwood (*Populus deltoides*), American elm (*Ulmus americanus*), sedges (*Carex* species), and asters (*Aster* species) vegetate both wetlands. Neither wetland is located within or adjacent to any of

the three project areas. Additionally, access roads to each of the project areas will be located away from the two wetlands. The wetlands currently serve as good wildlife habitat, provide floodwater storage, and supply groundwater recharge.

### 3.1.6 Biological and Habitat Integrity Survey

On June 10, 2004, JFNew surveyed the macroinvertebrate community of Carpenter Drain using the multihabitat approach detailed in the U.S. Environmental Protection Agency Rapid Bioassessment Protocols for Use in Wadeable Streams and Rivers, 2nd edition (Barbour et al., 1999). This method was supplemented by qualitative picks from substrate and by surface netting. Using data collected during this survey, JFNew calculated IDEM's macroinvertebrate Index of Biotic Integrity (mIBI) (IDEM, unpublished). IDEM's mIBI is a multi-metric index designed to provide a complete assessment of a stream's biological integrity. Karr and Dudley (1981) define biological integrity as "the ability of an aquatic ecosystem to support and maintain a balanced, integrated, adaptive community of organisms having a species composition, diversity, and functional organization comparable to the best natural habitats within a region."

The mIBI is designed to assess biotic integrity directly through ten metrics which evaluate a macroinvertebrate community's species richness, evenness, composition, and density within the stream. These metrics include the family-level HBI (Hilsenhoff's Family Biotic Index), number of taxa, number of individuals, percent dominant taxa, EPT index, EPT count, EPT count to total number of individuals, EPT count to Chironomid count, Chironomid count, and number of individuals per number of squares sorted. (EPT stands for the *Ephemeropteran*, *Plecopteran*, and *Trichopteran* orders.) After data from sampling sites have been collected, values for the ten metrics are compared with corresponding ranges and a rating of 0, 2, 4, 6, or 8 is assigned to each metric. The average of these ratings gives a total mIBI score, the best possible of which is 8.0. Macroinvertebrate communities in streams scoring less than 2 are considered severely impaired; these streams are rated by IDEM as non-supporting for their aquatic life use designation. Macroinvertebrate communities in streams scoring from 2 to 4 are considered moderately impaired and the associated streams are rated by IDEM as partially supporting their aquatic life use designation. Macroinvertebrate communities scoring from 4 to 6 and from 6 to 8 are rated as slightly impaired and non-impaired, respectively. These streams are designated as fully supporting of their aquatic life use designation as determined by IDEM.

Table 3 contains data from the biotic assessment of Carpenter Drain conducted on June 10, 2004; data sheets are included in Appendix D. The mIBI score calculated for Carpenter Drain (3.2) indicates that the macroinvertebrate community was moderately impaired and suggests that the stream was only partially supportive of its aquatic life use designation at the time of sampling. The most abundant macroinvertebrates at this site were members of the moderately pollution tolerant *Trichopteran* family *Hydropsychidae* and of the pollution tolerant *Dipteran* family *Chironomidae*. A high HBI score, low number of individuals, and a high dominance (58.3%) of the *Trichopteran* family *Hydropsychidae* characterize the macroinvertebrate community along this reach of Carpenter Drain.

**Table 3. mIBI Scores for the Carpenter Drain assessment reach as sampled June 10, 2004.**

| Metric | Value | Metric Score |
|---|---|---|
| HBI | 4.74 | 4 |
| Number of Taxa | 14 | 4 |
| Number of Individuals | 108 | 2 |
| Percent Dominant Taxa | 58.3 | 2 |
| EPT Index | 3 | 2 |
| EPT Count | 65 | 4 |
| EPT Count/Total Count | 0.60 | 6 |
| EPT Abundance/Chironomid Abundance | 2.95 | 4 |
| Total Number of Individuals per Square Sorted | 3.48 | 0 |
| Chironomid Count | 22 | 4 |
| **mIBI Score** | | **3.2** |
| **Integrity Class** | | **Moderately Impaired** |

Habitat was also evaluated on June 10, 2004 using the Qualitative Habitat Evaluation Index (QHEI) developed by the Ohio EPA for streams and rivers in Ohio (Rankin, 1989 and 1995). While the Ohio EPA originally developed the QHEI to evaluate fish habitat in streams, IDEM and other agencies routinely utilize the QHEI as a measure of general "habitat" health. Various attributes of the habitat are scored based on the overall importance of each to the maintenance of viable, diverse, and functional aquatic faunas. The type(s) and quality of substrate; amount and quality of in-stream cover; channel morphology; extent and quality of riparian vegetation; pool, riffle, and run development and quality; and gradient are the metrics used to determined the QHEI score. Each metric is scored individually then summed to provide the total QHEI score. QHEI scores typically range from 20 to 100.

The QHEI is used to evaluate the characteristics of a stream segment, as opposed to the characteristics of a single sampling site. As such, individual sites may have poorer physical habitat due to a localized disturbance yet still support aquatic communities closely resembling those sampled at adjacent sites with better habitat, provided water quality conditions are similar. QHEI scores from hundreds of stream segments in Ohio indicate that values greater than 60 are *generally* conducive to the existence of warmwater faunas. Scores greater than 75 typify conditions that have the ability to support exceptional warmwater faunas (Ohio EPA, 1999). IDEM indicates that QHEI scores above 64 suggest that the habitat is capable of supporting a balanced warmwater community; streams with scores between 51 and 64 are only partially supportive of a stream's aquatic life use designation. Streams that score less than 51 are considered non-supporting of their aquatic life use designation (IDEM, 2000).

The Carpenter Drain sampling reach received a QHEI score of 57 indicating that the stream habitat is fully supporting of its aquatic life use designation. (QHEI metric scores are listed in Table 4 with datasheets in Appendix D.) The overall QHEI score indicates that the habitat within this portion of Carpenter Drain should support the stream's aquatic life; however, individual habitat metrics suggest that habitat may be one of the factors impairing aquatic life in the creek. Scores for pool development (2 of 12), riffle development (2 of 8), channel morphology (12 of

20), and instream cover (12 of 20) were below those observed in streams with exceptional habitat. This lack of habitat likely contributes to depressed mIBI scores within Carpenter Drain.

**Table 4. QHEI Scores for the Carpenter Drain assessment reach as sampled June 10, 2004.**

| Site | Substrate Score | Cover Score | Channel Score | Riparian Score | Pool Score | Riffle Score | Gradient Score | Total Score |
|---|---|---|---|---|---|---|---|---|
| Maximum Possible Score | 20 | 20 | 20 | 10 | 12 | 8 | 10 | 100 |
| Carpenter Drain | 13 | 12 | 12 | 8 | 2 | 2 | 8 | 57 |

### 3.1.7 Environmental Impact Assessment

As already discussed, bank stabilization work using bioengineering techniques has been proposed along the mainstem of Carpenter Drain. Environmental considerations relevant to the proposed project include: wetlands, endangered, threatened, and rare (ETR) species, water quality, flooding, stream habitat, and stream biota. Streambank stabilization along Carpenter Drain can proceed with minimal impact to environmental factors. Although an endangered species survey was not conducted, the plant species documented in the Carpenter Drain project area did not include any state-listed species. Additionally, the IDNR Division of Nature Preserves (DNP) Natural Heritage Database does not contain documentation of any ETR plant species in the Carpenter Drain subwatershed. Additionally, no ETR animal species were documented during the survey; however, the IDNR DNP Heritage Database lists three ETR fauna in the drainage upstream of the project site. Since the proposed project will not impact the wetlands near the drain, it is assumed that these areas will continue to function as they have historically. The proposed bank stabilization project will not have any impact on flooding. Bank stabilization should lead to improved water quality in the stream and in Crooked Lake as bank erosion is slowed. Sediment and sediment-attached pollutant loading rates will also be slowed. Over the long-term, bank stabilization will result in more stable habitat within the stream. Rock added for toe stabilization will provide additional in-stream habitat, while vegetation planted between the lifts will provide stream cover. During construction, excavation and localized disturbance of the riparian zone has the potential to impair both water quality and habitat temporarily.

### 3.1.8 Unusual Physical and Social Costs

Unusual physical costs associated with design and construction of the project include: avoiding wetland areas, attaining access to the streambanks while keeping the forested riparian corridor intact, and disposal of refuse that has been previously discarded within the stream. Access areas are proposed in areas away from wetlands and in areas that minimize disturbance to the forested riparian corridor. Some trees may need to be removed during project construction.

### 3.1.9 Opinions of Probable Cost and Proposed Time Line

The opinion of probable cost is $27,750 for bank stabilization and debris removal at the Carpenter Drain project site (Table 5).

**Table 5. Opinion of probable cost for bank stabilization design and construction at the Carpenter Drain project site.**

| Item | Cost | Unit | Number | Total |
|---|---|---|---|---|
| Final design plans and permitting | $2,775 | each | 1 | $2,775 |
| Construction services | $2,775 | each | 1 | $2,775 |
| Administrative services | $3,700 | each | 1 | $3,700 |
| **Subtotal** | | | | **$9,250** |
| Fabric lifts (includes plants) | $80 | foot | 200 | $16,000 |
| Mobilization/demobilization | $2,500 | each | 1 | $2,500 |
| **Construction Subtotal** | | | | **$18,500** |
| **Total** | | | | **$27,750** |

The Crooked Lake Association applied for and received design-build LARE funding in early 2004. Services were contracted for the design-build project in late 2004 after the grant was awarded. Design of the project was completed in the winter of 2004-2005 with project construction slated to occur in early 2005.

### 3.1.10 Project Justification and Estimation of Impact

Although streambank erosion is a natural process, drainage practices in the Carpenter Drain subwatershed have artificially exacerbated the process. Artificial drainage of the Carpenter Drain subwatershed landscape increases the volume and velocity of water delivered to the channel during storm flow events. During high discharge events, rapid flows carry away bank material increasing the rate of lateral migration and formation of steep, eroded banks. The high gradient banks formed by erosion of bank material at the toe of the slope lead to mechanical bank failure. Ultimately, this results in the deposition of more material at the base of the slope where base flow discharges can carry the material downstream (Waters, 1995). As the slumped material is removed, bank slope is again increased and the process repeats itself. Cultural processes like artificial drainage exacerbate the problem by increasing the amplitude of discharge events. In a 1964 study of relationships among sediment, discharge, and land use, Striffler (1964) found that streams in cultivated and pastured watersheds had heavy sediment deposits and variable flows. Streambank erosion was identified as an important contributor to net sediment loading. Sharpley et al. (1999) documented that a majority of sediment and phosphorus in a stream originated from near stream runoff and channel erosion. Additionally, in some cases researchers have attributed >50% of the sediment load carried by small streams in the Midwest to channel erosion (Roseboom and White, 1990; Isenhart et al., 1997). The project becomes necessary when considering that the goal is ultimately to reduce the delivery of sediments to Crooked Lake, and all feasible actions to reduce sediment release from the watershed must be attempted prior to securing in-lake treatment funding.

## 3.2 Stormwater treatment along Palfreyman Drain, Steuben County Highway Department Facility

### 3.2.1 Site Description and Alternatives

The stormwater treatment project area is located within and adjacent to Palfreyman Drain near the intersection of County Road 200 North with County Road 200 West (Figure 1). The project

site includes a portion of the Steuben County Highway Department facility and approximately 300 lineal feet of Palfreyman Drain. The Palfreyman Drain subwatershed drains 1,765 acres (714 hectares or 2.75 square miles). The stream originates as a series of storm drains within the City of Angola and becomes an open drain behind Country Fair Shopping Center south of County Road 100 North. The stream drains predominantly agricultural, residential, and commercial land before entering Crooked Lake. The stream has a relatively high gradient falling from 1030 feet mean sea level to approximately 988 feet mean sea level at its confluence with Crooked Lake. Palfreyman Drain is a legal drain from its intersection with County Road 100 North to its intersection with County Road 200 West meaning that the Steuben County Surveyor's office can collect ditch assessment fees for this portion of the drain in order to maintain proper drainage. Because the entire length of Palfreyman Drain within the project site is a legal drain, the Steuben County Drainage Board must approve any potential projects.

The reach assessed during this feasibility study included approximately 300 lineal feet of the mainstem of Palfreyman Drain located within property owned by Steuben County. This portion of the stream channel possesses little sinuosity and high, steep streambanks indicating that the channel has been dredged and straightened in the past. Concurrent with dredging and straightening, the riparian canopy was removed and the immediate watershed land was converted from forest and wetland to agricultural and then commercial use. Fescue and a limited number of silver maple and elm trees vegetate the streambanks at this project site. Soils near the stream are loamy sands and sandy loams. The streambanks are uniformly steep throughout the project site measuring 7 to 11 feet in height. (See Appendix A for site photographs.)

Surface water enters the project site through a variety of pathways including riprap channels, overland flow, and drain pipes. At the steepest and most eroded locations, riprap channels installed from the top of the streambank down slope to the stream convey water to Palfreyman Drain. The riprap channels carry water from both County Road 200 North and the highway department facility into Palfreyman Drain. A total of seven riprap channels have been installed along this 300-foot reach of Palfreyman Drain. During runoff events, stormwater also flows from County Road 200 North directly over the streambank and into the stream channel carrying sediment, sediment-attached and dissolved pollutants, and debris into Palfreyman Drain. This occurs along the entire length of the project site. Finally, water from the highway department facility enters the stream via a 12-inch metal pipe. Water exiting this pipe is directed into the opposite (north) streambank, eroding the bank opposite the pipe outlet. Water exiting the pipe has also eroded the streambank below the pipe.

The goal of stormwater treatment within the project site is to at reduce the volume and velocity of water entering and moving through the stream. Alternatives include: placing stone on both the north and south streambanks along the length of the project site; constructing an infiltration trench at the top of the north bank along the length of the site; replacing the pipe with a vegetated swale or wetland creation at the county highway department facility; and any combination of these options. Due to the desire of the highway department to continue to utilize the area adjacent to the stream for storage of equipment and materials and limited space throughout the project site, a combination of the options listed above was selected for this project site. The agreed upon combination of stormwater management techniques is as follows: the construction of an infiltration trench at the top of the bank between Palfreyman Drain and County Road 200

North, the placement of stone along the northern streambank, and installation of a vegetated swale in place of the pipe located on the Steuben County Highway Department facility.

### 3.2.2 Easement and Land Availability Determination

The Steuben County Commissioners reviewed the proposed stormwater treatment techniques at their May 2004 meeting and approved the conceptual work. Presently, the Steuben County Highway Department uses the area adjacent to Palfreyman Drain for equipment and material storage. The proposed drainage swale is conceptually designed in a location currently occupied by a drainage inlet and pipe. The construction of this swale will not impede the usage of this area. The remaining portions of the project are located along the north streambank. Access to this portion of the project site can be obtained from the south streambank. The Steuben County Commissioners have signed a letter supporting the project as conceptually designed (Appendix B).

### 3.2.3 Preliminary Design and Conceptual Drawings

Three techniques are recommended to address stormwater and erosion issues along this reach of Palfreyman Drain. These techniques include: the construction of an infiltration trench and grass buffer between Palfreyman Drain and County Road 200 North, the placement of stone along the northern streambank, and the installation of a vegetated swale in place of the drain located on the highway department property. Figure 8 documents the conceptual plan view for the highway department project site.

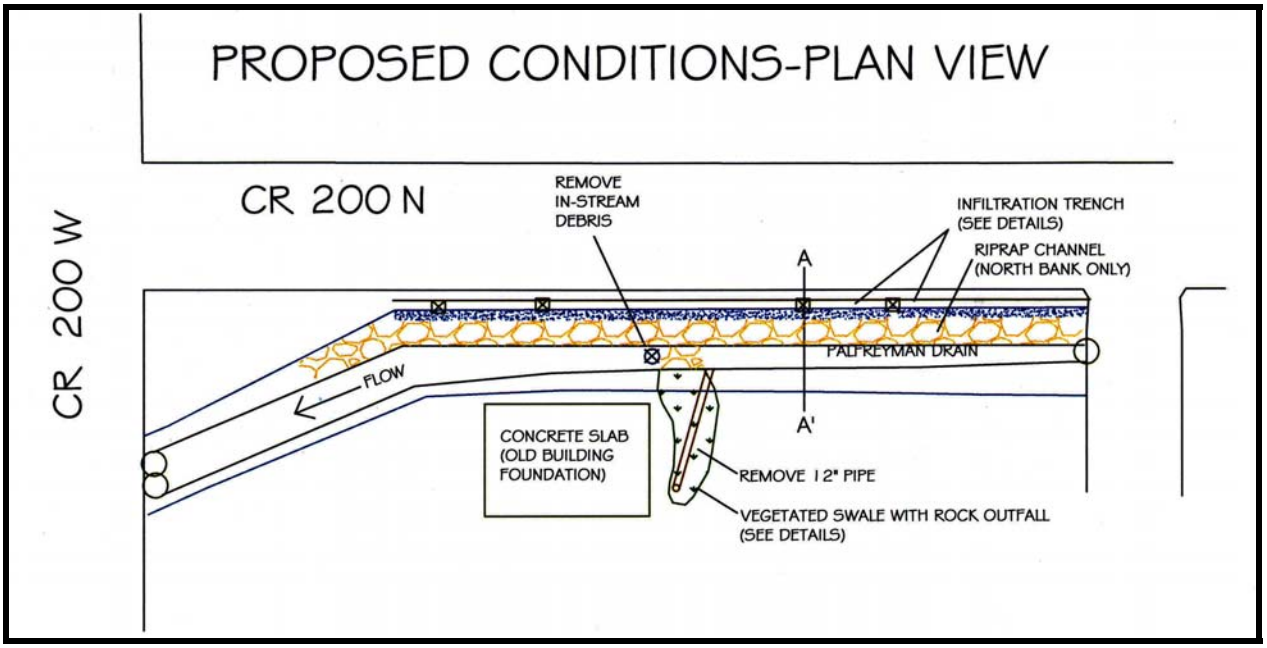


**Figure 8. Conceptual plan view of the Palfreyman Drain stormwater treatment project.**

The infiltration trench and grass buffer will be located along the length of the northern streambank from the Steuben County Highway Department access road to the southern bend in the stream (approximately 300 lineal feet). Runoff from County Road 200 North will filter through a grass buffer with a minimum width of 2 feet prior to entering the infiltration trench. The infiltration trench will run along the stream channel between the guard rail and the top of the

streambank for a total of approximately 300 lineal feet. Due to space limitations, the infiltration trench will not be installed in the area adjacent to the power pole approximately 125 feet west of the highway department facility entrance road. (The space available at the top of the bank is too narrow for the infiltration trench to be installed.) Along the remainder of the streambank, the trench will be excavated to a width and depth of 2-3 feet (Figure 9). The trench will then be filled with pea gravel, septic stone, and sand to encourage infiltration.

The grass buffer installed between County Road 200 North and the infiltration trench will reduce runoff velocity and collect roadside debris prior to it entering the infiltration trench. The infiltration trench will encourage the infiltration of stormwater runoff from County Road 200 North into the soil under and adjacent to the infiltration trench. This water will then enter the stream as groundwater rather than through overland flow thereby reducing sediment and sediment-attached pollutant loading to Palfreyman Drain. In order to ensure long-term usability of the grass buffer and infiltration trench, the trench will need to be inspected on an annual basis. The trench should also be inspected following a large storm event (10 year or greater). Annual inspection should consist of removing the pea gravel and filter fabric to inspect for sediment deposits. If the trench becomes clogged, then the trench should be restored to the original design.

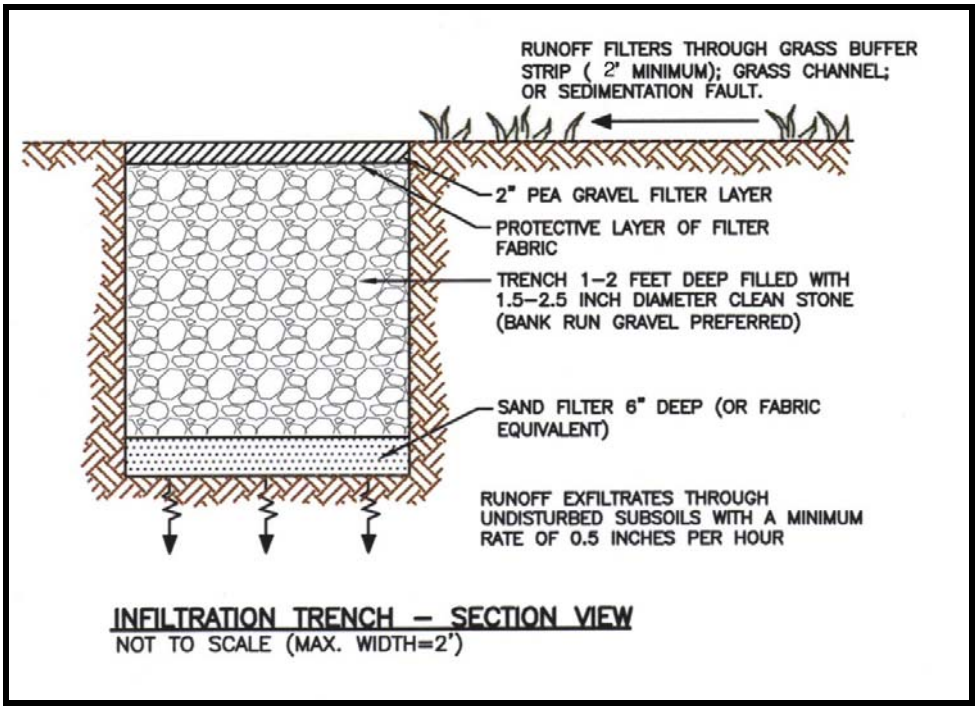


**Figure 9. Conceptual cross section view of the infiltration trench.**

The second portion of the project will address erosion present along the northern streambank via the installation of stone along the length of the project site (Figure 10). This treatment will extend approximately 350 feet. It will extend from the culvert at the highway department access drive to approximately 50 feet beyond the point where Palfreyman Drain bends to the south (Figure 8). The northern bank will be covered with filter fabric or erosion control blankets. Glacial rock will then be placed over the fabric. The installation of glacial stone will reduce the

area of exposed soil and curtail streambank erosion and sediment and sediment-attached pollutant loading to Crooked Lake.

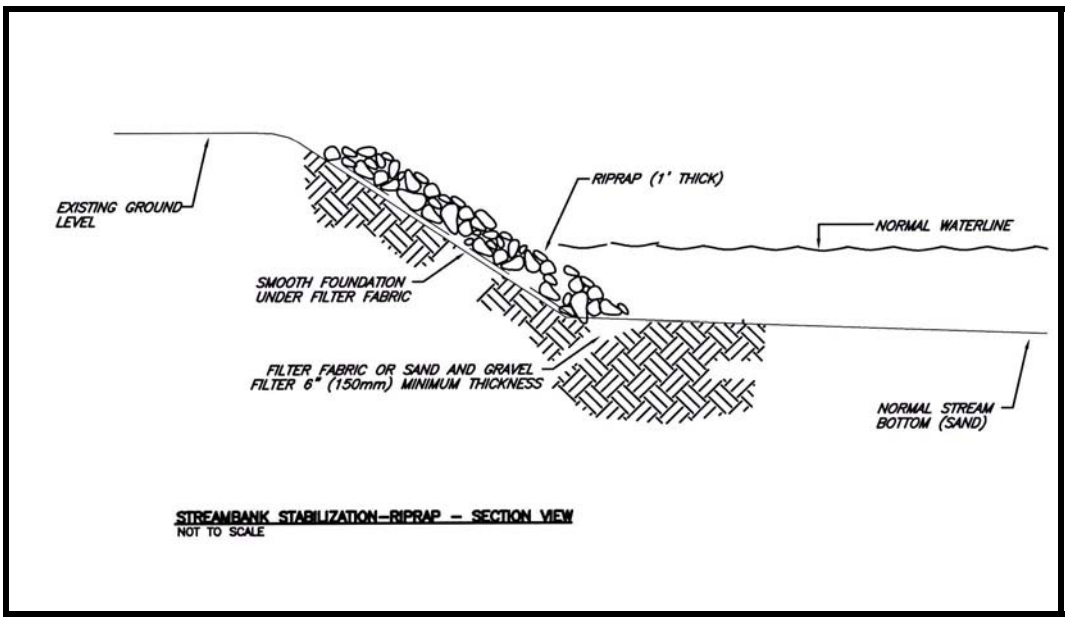


**Figure 10. Conceptual cross section view of streambank stabilization using stone.**

The third portion of the project includes the installation of a vegetated swale from the edge of the gravel parking area on the county highway department facility north to the southern streambank. The swale will replace the existing 12-inch metal pipe. The conceptual design includes the removal of the existing straight pipe structure and the installation of a 15-foot wide swale. The swale area will be excavated, filled with pea gravel and sand, and planted with prairie cord grass and refilled. The excavated area will be covered by a 6-inch layer of sand then covered with filter fabric to prevent the sand from washing into the stream. Small diameter (<2.5-inch) stone and pea gravel layers will cover the filter fabric. The area will then be planted with prairie cord grass (Figure 11). A rock outfall will be installed at the edge of the stream where water from the pipe currently in place has eroded the streambank. This will prevent future erosion. The vegetated swale will reduce sediment and sediment-attached pollutant loading to and decrease the volume and velocity of stormwater entering Palfreyman Drain from the Steuben County Highway Department Facility.

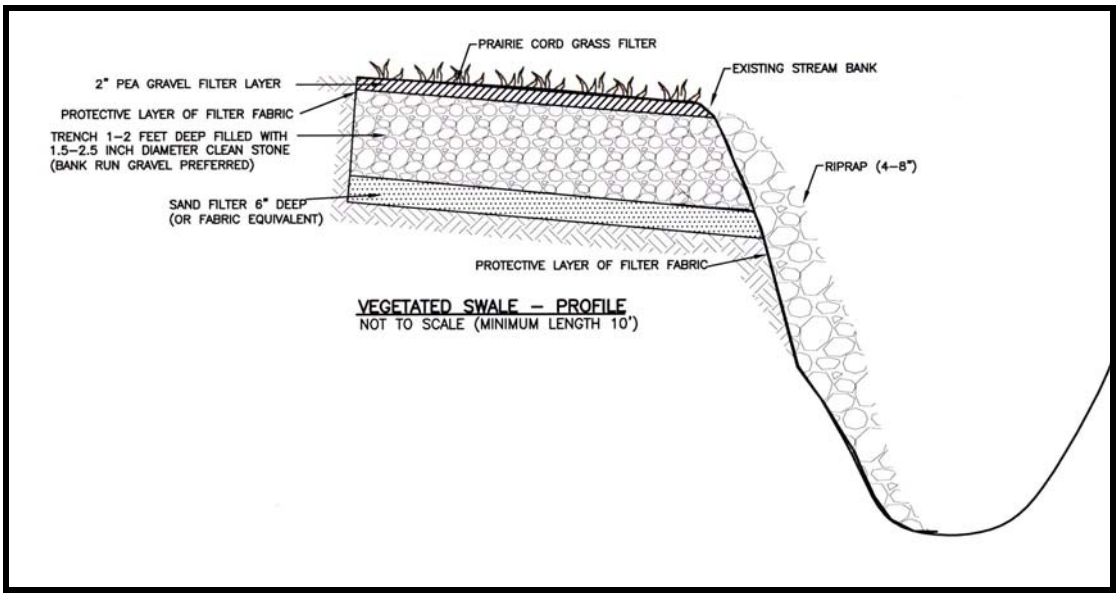


**Figure 11. Conceptual cross section of vegetated swale.**

### 3.2.4 Permit Requirements

Projects associated with Palfreyman Drain will require a permit from the Steuben Country Drainage Board since the stream is a legal drain. An IDNR construction in a floodway permit is necessary for this project since the drainage area upstream of the project site is greater than one square mile. A Section 401 Water Quality Certification from the IDEM and a Section 404 Permit from the Corps are required because Palfreyman Drain is a "waters of the United States." Preliminary comments were solicited from the Steuben County Surveyor's Office, the IDNR, the IDEM, and the Corps with this draft. Permit applications have not been submitted nor have permits been obtained for this project.

### 3.2.5 Wetland Functional Assessment

No wetlands are located within the vicinity of the project site.

### 3.2.6 Biological and Habitat Integrity Survey

On June 10, 2004, JFNew surveyed the macroinvertebrate community of Palfreyman Drain using the multihabitat approach detailed in the U.S. Environmental Protection Agency Rapid Bioassessment Protocols for Use in Wadeable Streams and Rivers, 2nd edition (Barbour et al., 1999). This method was supplemented by qualitative picks from substrate and by surface netting. Using data collected during this survey, JFNew calculated IDEM's macroinvertebrate Index of Biotic Integrity (mIBI) (IDEM, unpublished). IDEM's mIBI is a multi-metric index designed to provide a complete assessment of a stream's biological integrity. Karr and Dudley (1981) define biological integrity as "the ability of an aquatic ecosystem to support and maintain a balanced, integrated, adaptive community of organisms having a species composition, diversity, and functional organization comparable to the best natural habitats within a region."

The mIBI is designed to assess biotic integrity directly through ten metrics which evaluate a macroinvertebrate community's species richness, evenness, composition, and density within the stream. These metrics include the family-level HBI (Hilsenhoff's Family Biotic Index), number

of taxa, number of individuals, percent dominant taxa, EPT index, EPT count, EPT count to total number of individuals, EPT count to Chironomid count, Chironomid count, and number of individuals per number of squares sorted. (EPT stands for the *Ephemeropteran*, *Plecopteran*, and *Trichopteran* orders.) After data from sampling sites have been collected, values for the ten metrics are compared with corresponding ranges and a rating of 0, 2, 4, 6, or 8 is assigned to each metric. The average of these ratings gives a total mIBI score, the best possible of which is 8.0. Macroinvertebrate communities in streams scoring less than 2 are considered severely impaired; these streams are rated by IDEM as non-supporting for their aquatic life use designation. Macroinvertebrate communities in streams scoring from 2 to 4 are considered moderately impaired and the associated streams are rated by IDEM as partially supporting their aquatic life use designation. Macroinvertebrate communities scoring from 4 to 6 and from 6 to 8 are rated as slightly impaired and non-impaired, respectively. These streams are designated as fully supporting of their aquatic life use designation as determined by IDEM.

Table 6 contains data from the biotic assessment of Palfreyman Drain conducted on June 10, 2004; data sheets are included in Appendix D. The mIBI score calculated for Palfreyman Drain (2.4) indicates that the macroinvertebrate community was moderately impaired. The score suggests that the stream was only partially supporting for its aquatic life use designation at the time of sampling. The most abundant macroinvertebrates at this site were members of the moderately pollution tolerant *Coleopteran* family *Elmidae* and *Trichopteran* family *Hydropsychidae*. Freshwater sponge of the family *Spongillidae* was also observed within Palfreyman Drain. Freshwater sponges are typically associated with clear water in higher quality streams but may be found attached to rocks or woody debris in any shallow lake, river, or stream (McCafferty, 1981). A high HBI score, low density (number of individuals) and diversity (number of taxa), and a dominance (49.5%) of the *Coleopteran* family *Elmidae* characterize the macroinvertebrate community along this reach of Palfreyman Drain.

**Table 6. mIBI Scores for the Palfreyman Drain assessment reach as sampled June 10, 2004.**

| Metric | Value | Metric Score |
|---|---|---|
| HBI | 4.57 | 4 |
| Number of Taxa | 10 | 2 |
| Number of Individuals | 101 | 2 |
| Percent Dominant Taxa | 49.5 | 2 |
| EPT Index | 4 | 4 |
| EPT Count | 20 | 2 |
| EPT Count/Total Count | 0.20 | 2 |
| EPT Abundance/Chironomid Abundance | 0.95 | 2 |
| Total Number of Individuals per Square Sorted | 4.04 | 0 |
| Chironomid Count | 21 | 4 |
| **mIBI Score** | | **2.4** |
| **Integrity Class** | | **Moderately Impaired** |

Habitat was also evaluated on June 10, 2004 using the Qualitative Habitat Evaluation Index (QHEI) developed by the Ohio EPA for streams and rivers in Ohio (Rankin, 1989 and 1995).

While the Ohio EPA originally developed the QHEI to evaluate fish habitat in streams, IDEM and other agencies routinely utilize the QHEI as a measure of general "habitat" health. Various attributes of the habitat are scored based on the overall importance of each to the maintenance of viable, diverse, and functional aquatic faunas. The type(s) and quality of substrate; amount and quality of in-stream cover; channel morphology; extent and quality of riparian vegetation; pool, riffle, and run development and quality; and gradient are the metrics used to determined the QHEI score. Each metric is scored individually then summed to provide the total QHEI score. QHEI scores typically range from 20 to 100.

The QHEI is used to evaluate the characteristics of a stream segment, as opposed to the characteristics of a single sampling site. As such, individual sites may have poorer physical habitat due to a localized disturbance yet still support aquatic communities closely resembling those sampled at adjacent sites with better habitat, provided water quality conditions are similar. QHEI scores from hundreds of stream segments in Ohio indicate that values greater than 60 are *generally* conducive to the existence of warmwater faunas. Scores greater than 75 typify conditions that have the ability to support exceptional warmwater faunas (Ohio EPA, 1999). IDEM indicates that QHEI scores above 64 suggest that the habitat is capable of supporting a balanced warmwater community; scores between 51 and 64 are only partially supportive of a stream's aquatic life use designation, while scores less than 51 are considered non-supporting for the stream's aquatic life use designation (IDEM, 2000).

QHEI metric scores are listed in Table 7 with datasheets in Appendix D. The Palfreyman Drain sampling reach received a QHEI score of 39 indicating that the stream habitat is non-supporting of its aquatic life use designation. The overall QHEI score indicates that habitat may be one factor impairing aquatic life in the creek. The lack of pool and riffle development, poor instream cover, and a narrow riparian zone characterize the habitat at this reach. Scores for pool development (0 of 12), riffle development (1 of 8), channel morphology (6.5 of 20), instream cover (5 of 20), and riparian zone development (3.5 of 10) were below those observed in streams with exceptional habitat. This lack of habitat likely contributes to depressed mIBI scores within Palfreyman Drain.

**Table 7. QHEI Scores for the Palfreyman Drain assessment reach as sampled June 10, 2004.**

| Site | Substrate Score | Cover Score | Channel Score | Riparian Score | Pool Score | Riffle Score | Gradient Score | Total Score |
|---|---|---|---|---|---|---|---|---|
| Maximum Possible Score | 20 | 20 | 20 | 10 | 12 | 8 | 10 | **100** |
| Palfreyman Drain | 13 | 5 | 6.5 | 3.5 | 0 | 1 | 10 | **39** |

### 3.2.7 Environmental Impact Assessment

As already discussed, stormwater treatment has been proposed along Palfreyman Drain at the Steuben County Highway Department facility. Environmental considerations relevant to the proposed project include: wetlands; endangered, threatened, and rare species; water quality; flooding; stream habitat; and stream biota. The proposed stormwater treatment project can proceed with minimal negative environmental impact. No wetlands are located within or adjacent to the proposed project site. The stream's biotic integrity was rated as moderately impaired in the spring of 2004 macroinvertebrate community assessment. This suggests that the

site has been previously impacted by anthropogenic factors. Macroinvertebrate communities observed in Palfreyman Drain are dominated by moderately tolerant to tolerant species that are adapted to human-induced environmental stress. JFNew biologists did not observe or collect any endangered, threatened, or rare flora or fauna during the site visits. Furthermore, the IDNR Division of Nature Preserves Natural Heritage Database does not document any ETR species within or downstream of the proposed project site. The installation of an infiltration trench and vegetated swale will slow overland flow, thereby reducing the flow of sediment and sediment-attached pollutants from County Road 200 North into Palfreyman Drain along the length of the project site. The placement of stone on the northern bank of Palfreyman Drain along the length of the project site will reduce erosion along this streambank. The reduction in erosion will in turn reduce sediment and sediment-attached pollutant loading to Palfreyman Drain. Overall, the proposed stormwater reduction project will result in an improvement of water quality. Additionally, rock added along the northern streambank for stabilization purposes will offer in-stream habitat.

### 3.2.8 Unusual Physical and Social Costs

Unusual physical and social costs associated with design and construction of the proposed stormwater reduction project include: attaining access to the streambanks while maintaining traffic flow along County Road 200 North, maintaining storage space at the Steuben County Highway Department facility, and disposing of refuse previously discarded in Palfreyman Drain. Project construction will occur from the highway department facility allowing for traffic flow along County Road 200 West to continue as normal. The project is located away from storage piles and will allow for continued use of the space by the highway department.

### 3.2.9 Opinions of Probable Cost

The opinion of probable cost is $38,610 for the construction of an infiltration trench between Palfreyman Drain and County Road 200 North, the placement of stone along the length of the north streambank, and the installation of a vegetated swale in place of the drain located on the Steuben County Highway Department property (Table 8). Costs could be reduced if the highway department constructs the project themselves rather than hiring an outside contractor.

The recommended project timeline is based on LARE grant funding cycles. It is recommended that the Crooked Lake Association apply for design-build funding in January 2006, contract design-build services in 2006, and design and construct the project in the fall of 2006. Alternatively, the proposed project could be constructed on an earlier timeline with local funding.

**Table 8. Opinion of probable cost for the stormwater reduction project at the Steuben County Highway Department facility. Item costs include delivery and installation.**

| Item | Cost | Unit | Number | Total |
|---|---|---|---|---|
| Final design plans and permitting | $4,700 | each | 1 | $4,700 |
| Construction services | $4,700 | each | 1 | $4,700 |
| Administrative services | $3,350 | each | 1 | $3,350 |
| **Subtotal** | | | | **$12,750** |
| Mobilization/demobilization | $2,500 | each | 1 | $2,500 |
| Stone | $35 | ton | 400 | $14,000 |
| Filter fabric | $2 | square yard | 560 | $1,120 |
| Sand | $20 | ton | 100 | $2,000 |
| Pea gravel | $20 | ton | 20 | $400 |
| Bank run | $16 | ton | 65 | $1,040 |
| Plant plugs | $4 | each | 190 | $760 |
| Swale mix | $400 | acre | 0.25 | $100 |
| Erosion fabric | $4 | square yard | 33 | $132 |
| Excavation | $9 | cubic yard | 162 | $1,458 |
| **Construction Subtotal** | | | | **$23,510** |
| Construction Contingency | | 10% of construction subtotal | | $2,350 |
| **Total** | | | | **$38,610** |

### 3.2.10 Project Justification and Estimation of Impact

Runoff along this reach of Palfreyman Drain has not been quantified; therefore, only limited conclusions regarding the amount of pollutants that this specific location delivers to Palfreyman Drain, and thus Crooked Lake, can be drawn. Regardless of the fact that exact quantities are not known, some pollutants generally associated with residential and commercial land uses are likely entering Palfreyman Drain at this location. Anecdotal documentation and observations recorded during this study indicate that trash, vegetation/organic debris, coarse and fine sediments, lawn fertilizers, heavy metals, and petroleum hydrocarbons are likely of greatest concern for this reach of Palfreyman Drain. A review of gray literature suggests that the installation of an infiltration trench and a vegetated swale at this project site will reduce urban pollutant loading to Palfreyman Drain. The USEPA (1999b), Michigan Department of Environmental Quality (2004), and the Atlanta Regional Commission (2004) indicate a 90% reduction in total suspended solids, a 60% reduction in total phosphorus and total nitrogen, and a 90% reduction in pathogens, metals, and hydrocarbons is possible when a vegetated swale-infiltration trench combination, like the one recommended for the northern streambank, is correctly installed and fully functioning. Similar results have been documented for fully functioning, dry vegetated swales, such as the one recommended for the highway department facility; however, treatment efficiencies are somewhat lower. Vegetated swales can remove 80% of suspended solids, 40-50% of total nitrogen, 10-50% of total phosphorus, and 60% of hydrocarbons (USEPA, 1999a; Atlanta Regional Commission, 2004).

The third portion of the stormwater treatment project at this reach of Palfreyman Drain includes streambank stabilization along the north streambank. Streambank erosion is a natural process; however, drainage practices in the Palfreyman Drain subwatershed have artificially exacerbated the process. Artificial drainage of the Palfreyman Drain watershed landscape increases the

volume and velocity of water delivered to the channel during storm flow events. During high discharge events, rapid flows erode bank material increasing the steepness of the streambanks (Ferguson and Deak, 1994). The steep banks lead to mechanical bank failure and deposition of more material at the base of the slope where base flow discharges can carry the material downstream (Waters, 1995). As the slumped material is removed, bank slope is again increased and the process repeats itself. Cultural processes, like artificial drainage, exacerbate the problem by increasing the amplitude of discharge events (Tourbier, 1994). Streambank erosion has historically been identified as an important contributor to net sediment loading in Palfreyman Drain (William Hill and Associates, 1989). Roseboom and White (1990) and Isenhart et al. (1997) attributed >50% of the sediment load carried by small streams in the Midwest to channel erosion. Stabilizing the northern streambank with stone will reduce the amount of soil exposed to the erosive forces of the stream, thereby reducing sediment loading to Palfreyman Drain and eliminating mechanical bank failure along this reach.

## 3.3 Stormwater Treatment, Steuben County 4-H Park

### 3.3.1 Site Description and Alternatives

The Steuben County 4-H Park is located within the 95-acre parcel owned and maintained as the Steuben County Park and Steuben County 4-H Park. The 4-H park encompasses approximately one-third of this parcel. The area assessed during this feasibility study included the main portion of the 4-H park extending from Carpenter Drain west to the tree line and from Crooked Lake south to the gravel entrance drive south of the majority of the animal barns (Figure 12). Much of the 4-H park consists of mowed grass, barns, gravel driveways, and patches of trees. The relatively steep topography of the property slopes from the southern portion of the property north to Crooked Lake, falling approximately 40 feet over the quarter mile distance. Stormwater runoff flows over the mowed grass areas and gravel driveways before flowing downhill to Crooked Lake.

During rain events, water moves across exposed soils and along gravel driveways carrying sediment and sediment-attached pollutants from the Steuben County 4-H Park to Crooked Lake. Stormwater from the eastern portion of the park flows across mowed grass and exposed soils before running down a hill along two gravel driveways. The water then crosses the park entrance road before flowing through an unvegetated swale to Carpenter Drain. Rill and gully erosion present along much of the length of these driveways provides evidence of the rapid transport of water from this portion of the park along the driveways. Stormwater from the western portion of the property flows across mowed grass, unvegetated ground, and down multiple gravel driveways before collecting at a catch basin south of County Road 175 West. This catch basin also collects wash water from the washing station located between the dairy and calf barns (Figure 12). Water flows from the cistern located below the wash stations into a 6-inch plastic pipe to the catch basin. Water exits the catch basin through an 8-inch metal pipe and flows directly into Crooked Lake.


**Figure 12. Stormwater reduction project site at the Steuben County 4-H Park.**

The site currently contributes sediment and sediment-attached pollutants to Crooked Lake during storm events and periods of washing station usage. Additionally, the flow of stormwater down the gravel driveways carries sediment and sediment-attached pollutants to Carpenter Drain. These sediments are accumulating at the mouth of Carpenter Drain forming a sediment delta. A reduction in the volume and velocity of stormwater and wash water flowing across and leaving the site would result in the reduction in the amount of gravel required to maintain the park's roads; the delivery of sediment, phosphorus, and pathogens from dairy wash stations; the amount of sediments and nutrients leaving the site; and the accumulation of sediment at the mouth of Carpenter Drain. Consequently, an improvement in Crooked Lake's water quality would result from stormwater treatment that reduces the volume and velocity of stormwater and wash water leaving the 4-H park.

Potential stormwater treatment projects considered at the 4-H park include: paving existing gravel roads, moving existing gravel roads to less erosive areas, installing water bars across existing gravel roads and along the length of the existing wash water pipe, running the wash water pipe to the park's septic system and treating the water through the septic system, installing pollutant filters within the wash water holding tank, creating drainage swales along existing gravel roads, installing and planting rain gardens, creating a sediment basin between the 4-H park and Carpenter Drain, and any combination of these options. Because paving roadways can be costly (estimated to cost $18,000 for only the sloped roads targeted during this project not including any maintenance or upkeep) and creates additional impervious surfaces, which could

cause additional water quality issues, this option is not recommended at this time. However, it is important to keep in mind that paving will likely result in the greatest reduction in sediment loading to Crooked Lake from the gravel roadways. Furthermore, this option is not likely to be paid for through the LARE program. The Steuben County Parks Department may wish to investigate this option further in the future. Because the roads have long been established, moving the road to less erosion areas is not a feasible option. Restricting access to the current roads will be difficult likely resulting in individuals driving on or through newly vegetated areas. The park's septic system is not adequately sized to handle runoff from the dairy washing station; therefore, this is not a viable option for treating the wash water at this time. Filters could be installed in the inlet to the wash water catch basin; however, these filters will likely not provide as great a benefit in terms of pollutant removal as that available via biofilters. Additionally, the costs associated with the filters do not allow them to be a viable solution for pollutant removal in this situation. Likewise, because of the expense of and space requirements associated with sediment basin construction, this option was also not pursued. A combination of the remaining options, including installing water bars across existing gravel driveways, creating drainage swales along the driveways, and installing and planting rain gardens, will result in the greatest reduction of sediment and pollutant loading to Crooked Lake.

### 3.3.2 Easement and Land Availability Determination

The initial inspection of this project site occurred during the 2004 Steuben County 4-H Fair. This allowed for an assessment and identification of potential water quality issues during peak site usage. Presently, neither the Steuben County Commissioners nor the 4-H board has definite plans for alterations to the park facility, suggesting the location of the proposed project is available for design and construction. The Steuben County Commissioners reviewed the proposed gravel bar, drainage swale, and rain garden installation techniques at their August 2004 meeting and approved the conceptual work. The Steuben County Commissioners have signed a letter supporting the project as conceptually designed (Appendix B).

### 3.3.3 Preliminary Design and Conceptual Drawings

Three techniques are recommended to address stormwater and wash water runoff from the Steuben County 4-H Park. These techniques include the installation of a series of water bars along each of the targeted gravel roads, construction of gravel-filled drainage swales adjacent to the targeted gravel roads, and installation of two rain gardens. Figure 13 documents the conceptual plan view for the 4-H park stormwater treatment project.

Water bar or cross log installation will occur along each of the gravel roads marked for drainage swale installation in Figure 13. Gravel roads will be resloped to direct water across the road rather than allowing it to continue to flow down the center carrying sediment and sediment-attached nutrients to Crooked Lake. A series of water bars or cross logs installed across the gravel road will direct stormwater off of the gravel road into the drainage swale. Water bar installation will consist of the placement of two to three logs, depending upon the road's gradient, approximately 60 degrees off center of the flow of water (Figure 14). Logs will be anchored along the length of the log using rebar and at each end with glacial stone or riprap (Figure 15).

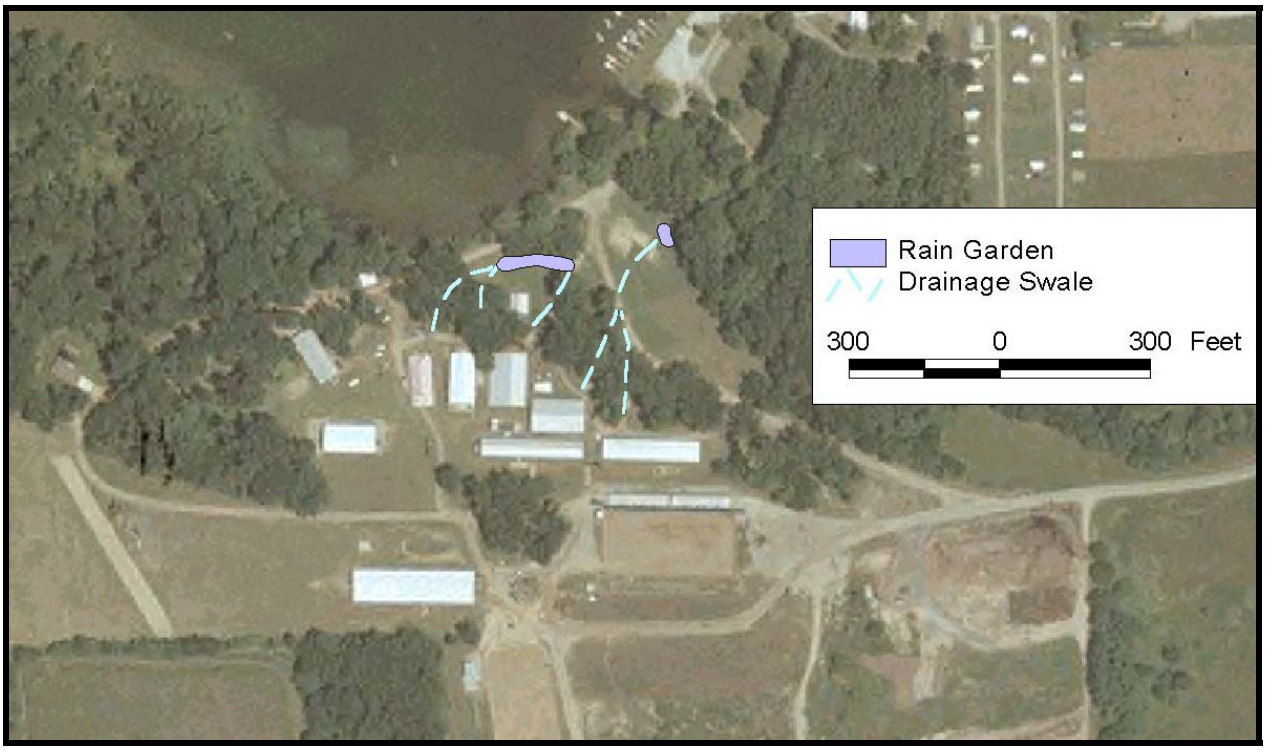


**Figure 13. Conceptual plan view of the 4-H park stormwater treatment project.**

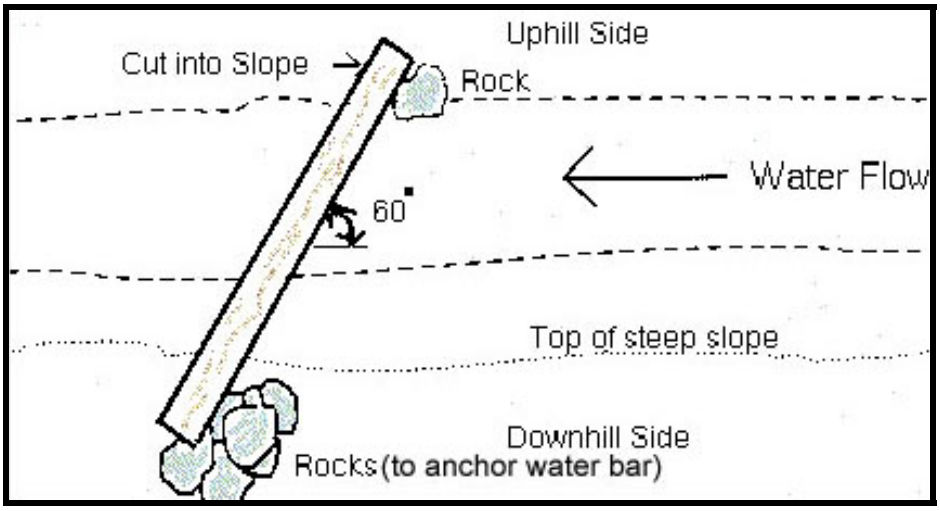


**Figure 14. Conceptual water bar installation, plan view.**

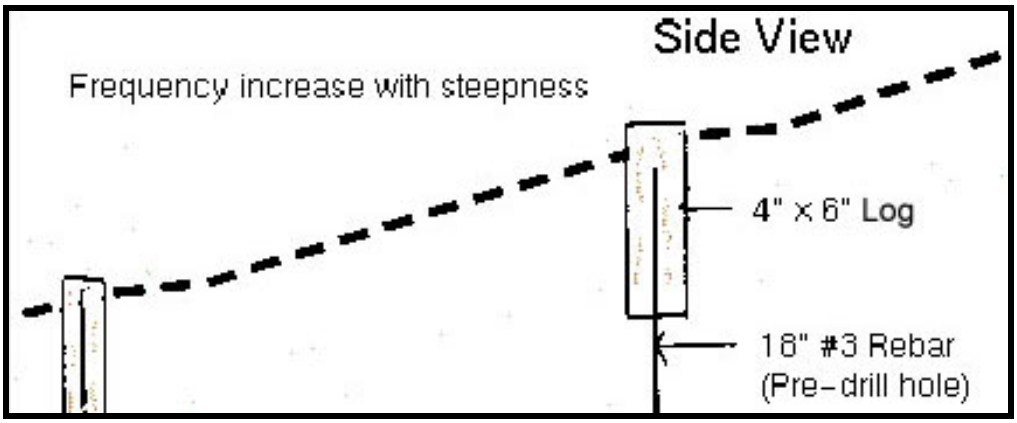


**Figure 15. Conceptual water bar installation, side view.**

Drainage swales will be installed along the length of the existing gravel roads (Figure 13). Runoff from the gravel roads will collect in drainage swales running adjacent to the gravel roadways. The drainage swales will be excavated to a width and depth of 2-3 feet (Figure 16). A 4 to 6-inch perforated plastic pipe will be installed along the length of the swale. The remainder of the swale will then be filled with pea gravel, septic stone, and glacial stone or riprap. The drainage swale will carry water from the gravel roadways to the rain gardens (Figure 13). This will reduce overland flow along the gravel roads, thereby reducing rill and gully erosion and sediment and sediment-attached pollutant transport to Crooked Lake. An additional drainage swale will be installed from the dairy washing facilities to the western rain garden. The installation of these drainage swales will allow sediment and nutrients to deposit within the rain garden rather than being transported directly to Crooked Lake. Additionally, the swales will be able to withstand the rigors of 4-H Fair traffic allowing individuals to park on and along existing roadways.

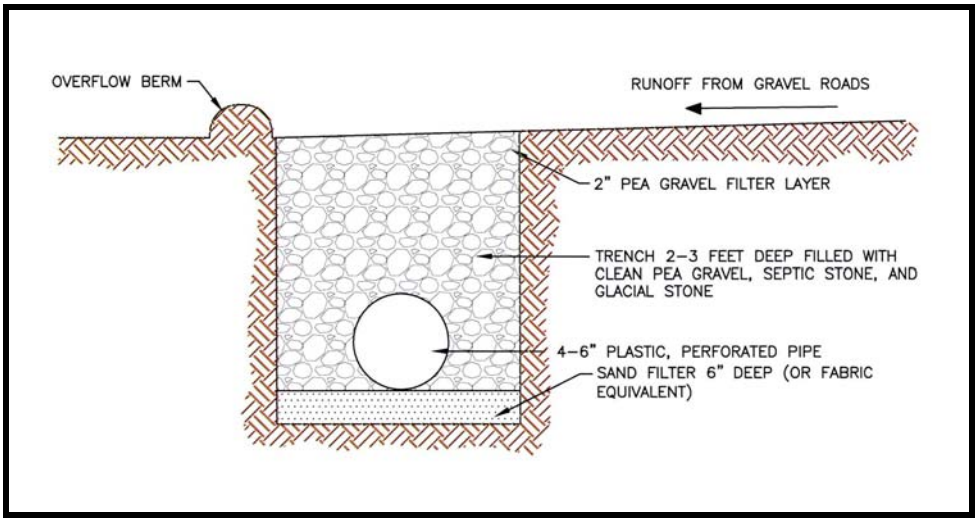


**Figure 16. Conceptual cross section view of the drainage swale.**

Two rain gardens will be installed to collect stormwater runoff at the end of the unvegetated swales. One rain garden will be installed near the eastern edge of the 4-H Park, while the second will be installed immediately south of the existing catch basin (Figure 13). Water will enter the

rain gardens as overland flow, through drainage swales adjacent to the existing gravel driveways, and via a drainage swale from the wash water station. Water will leave the eastern rain garden as subsurface flow to Carpenter Drain. Water from the western rain garden will also exit as subsurface flow; however, a pipe connecting the rain garden to the existing catch basin will carry any overflow water to the catch basin, if necessary. Rain gardens are bowl-shaped gardens designed to absorb and filter stormwater (Figure 17). Rain gardens protect lakes and streams from typical lawn fertilizers and pesticides, oil and other fluids from leaking cars, and other pollutants such as sediment and phosphorus from roofs and gravel or paved areas (UWEX, 2003). A rain garden resembles a typical flower garden planted with perennial, deep-rooted native plants and provides landscaping and wildlife habitat while filtering stormwater runoff. Rain gardens are constructed as an oval, with a berm to contain stormwater and mulch to stabilize the surface and reduce weed growth. A variety of perennial plant species can be planted within the rain garden, the exact mix of species will be determined during the design phase of the project.

**Figure 17. Representative photographs of conceptual rain garden designs.** Source: Maplewood, Minnesota, 2004.

### 3.3.4 Permit Requirements

An IDNR permit is not required for the proposed project. The proposed project does not occur in the floodway of or within a state waterway nor will excavation of the rain garden occur below the normal lake water level of Crooked Lake. A Section 401 Water Quality Certification from the IDEM and Section 404 Permit from the Corps are not required for the proposed project because the project does not occur in any "waters of the United States".

### 3.3.5 Wetland Functional Assessment

No wetlands are located within the project site; however, one wetland is located between the eastern rain garden and Carpenter Drain (Figure 6). Dogwood, cottonwood, American elm, sedges, and asters vegetate this wetland. All construction activities will occur outside of this wetland.

### 3.3.6 Biological and Habitat Integrity Survey

No streams or waterbodies are located on the project site. Half of the project site drains directly into Crooked Lake. Biological and habitat integrity was not surveyed for this portion of the project. The other half of the project site drains into Carpenter Drain then into Crooked Lake. Biological and habitat integrity of Carpenter Drain was assessed as part of the Carpenter Drain streambank stabilization project. Results of that survey are included in Section 3.1.6.

### 3.3.7 Environmental Impact Assessment

Environmental considerations relevant to the proposed project include: wetlands, endangered, threatened, and rare species, water quality, flooding, stream habitat, and stream biota. The stormwater treatment project is located entirely within the Steuben County 4-H Park, which consists of mowed grass, animal barns, gravel driveways, and patches of trees. The project site is located outside of any wetlands; therefore, wetlands will not be impacted during this project. The dominant plant species located within and adjacent to the project site are mowed fescue, maple and oak trees, and multiple weedy species including Queen Anne's lace and dandelions. No endangered, threatened, or rare flora or fauna were observed on the project site, nor are any ETR species included in the IDNR Division of Nature Preserves database. The project is located outside of Carpenter Drain and its floodplain; therefore, there will be no negative impact on stream habitat, stream biota, or flooding. The creation of rain gardens will provide additional water storage and stormwater filtration resulting in reduced sediment and sediment attached nutrient loading to Carpenter Drain and Crooked Lake.

### 3.3.8 Unusual Physical and Social Costs

Unusual physical and social costs associated with the design and construction of the project includes: potential loss of parking during peak park usage and rain garden maintenance and upkeep.

### 3.3.9 Opinions of Probable Cost

The opinion of probable cost is $60,370 for installing water bars, resloping gravel roads, creating drainage swales, and designing and constructing rain gardens (Table 9).

**Table 9. Opinion of probable cost for the proposed stormwater reduction project at the Steuben County 4-H Park.**

| Item | Cost | Unit | Number | Total |
|---|---|---|---|---|
| Final design plans and permitting | $5,750 | each | 1 | $5,750 |
| Construction services | $5,750 | each | 1 | $5,750 |
| Administrative services | $5,750 | each | 1 | $5,750 |
| **Subtotal** | | | | **$17,250** |
| Mobilization/demobilization | $2,500 | each | 1 | $2,500 |
| Excavation for drainage swales | $9 | cubic yard | 310 | $2,790 |
| Drain pipe for drainage swales | $6 | lineal foot | 925 | $5,550 |
| Pea gravel for drainage swales | $12 | ton | 275 | $3,300 |
| Erosion fabric for drainage swales | $3.50 | square yards | 670 | $2,345 |
| Water bars | $300 | each | 10 | $3,000 |
| Excavation for rain gardens | $9 | cubic yard | 850 | $3,750 |
| Mulch for rain gardens | $45 | tons | 20 | $900 |
| Plant plugs and seed mix | $1 | square foot | 6,000 | $6,000 |
| **Construction Subtotal** | | | | **$30,135** |
| Construction Contingency | | 10% of construction subtotal | | $3,014 |
| **Total** | | | | **$50,399** |

The recommended project timeline is based on grant funding cycles and peak summertime usage of the park and associated facilities. It is recommended that the CLA apply for design funding

through the LARE program in early 2005, contract design services in late 2005 after grant award, and design the project in the winter of 2005/2006. The CLA should apply for Great Lakes Sediment Control Funding for construction of the project designed through the LARE program. Construction should be completed in 2006. If construction cannot be completed prior to June 2006, then construction should be delayed until September 2006 to avoid peak usage periods at the 4-H Park.

### 3.3.10 Project Justification and Estimation of Impact

Pollutant export from the project site was not quantified as part of this project; therefore, only limited conclusions can be drawn regarding the amount of pollutants that this property delivers to Crooked Lake and what function the proposed solution will have. Mowed grass and gravel roadways in the park do little to reduce overland flow of stormwater and sediment and sediment-attached pollutant loading to Crooked Lake. Research indicates specific urban and suburban land uses present at the Steuben County 4-H Park can negatively impact water quality (Bannerman et al., 1992; Steuer et al., 1997; and Waschbusch et al., 2000). Bannerman et al. (1992) and Steuer et al. (1997) found high mean phosphorus concentrations in runoff from residential lawns (2.33-2.67 mg/L) and residential streets (0.14-1.31 mg/L). These concentrations are well above the threshold at which lakes might begin to experience algae blooms. (Research indicates that lakes with total phosphorus concentrations above 0.03 mg/L will likely experience algae blooms (Correll, 1998).)

Installation of the proposed project components including water bars, drainage swales, and rain gardens will reduce sediment and sediment-attached pollutant loading via a variety of mechanisms. Installing water bars and resloping the gravel roadways will redirect the flow of stormwater. This will help keep more gravel and sand on the roads, rather than allowing stormwater to carry gravel and sand down slope and into Crooked Lake. Stormwater from the project site will be transported into the two rain gardens. The rain gardens will act as short-term water storage basins holding water for approximately 48 hours. This additional retention time will allow for approximately 30% more stormwater to infiltrate into the ground than infiltration capacity provided by mowed grass (RGWM, 2004). Additionally, plant materials present in the rain gardens will act as filters and can reduce copper, lead, zinc, ammonia-nitrogen, and phosphorus loading by 60 to 80% (Winogradoff, 2002).

## 3.4 Stream reconstruction along Palfreyman Drain from its Headwaters to its Intersection with County Road 200 North

### 3.4.1 Site Description and Alternatives

The stream reconstruction project area covers the entirety of Palfreyman Drain from its headwaters to the point where is parallels County Road 200 North (Figure 1). The project includes two series of urban storm drains located 1) south of Country Fair Shopping Center and 2) along Harcourt Road and approximately 10,500 lineal feet (3,200 m) of open drain. The entirety of the open drain included in the project site is marked in orange in Figure 18. Additional storm drains are not marked in Figure 18 but are included in the project site. The stream's watershed has a relatively steep topography falling from 1030 feet mean sea level near the headwaters of Palfreyman Drain to approximately 988 feet mean sea level at the drain's confluence with Crooked Lake. Palfreyman Drain is a legal drain from its intersection with

County Road 100 North to its intersection with County Road 200 West meaning that the Steuben County Surveyor's office can collect ditch assessment fees for this portion of the drain in order to maintain proper drainage. Because the majority of the Palfreyman Drain project site is a legal drain, the Steuben County Drainage Board must approve any potential projects.

**Figure 18. Stream reconstruction project site (indicated in orange).**

The Palfreyman Drain subwatershed drains 1,765 acres (714 ha or 2.75 square miles). Historically, forests vegetated by oak, black walnut, ash, beech, maple, sycamore, and tamarack trees covered much of the subwatershed. Prairies and marshes covered the remainder of the drainage area (Baskins, Forster and Company, 1876). Following settlement, the subwatershed was cleared and converted to agricultural use. More recently, the landscape has been altered again to accommodate residential and commercial land uses. Currently, the stream drains a mix of agricultural, residential, and commercial land before entering Crooked Lake. Residential and commercial development continues throughout the subwatershed and is concentrated in the watershed's headwaters near Angola.

The Kosciusko-Ormas-Boyer soil association covers the majority of the open drain portion of Palfreyman Drain (Farmer, 1981). Kosciusko soils account for nearly 35% of the soil association; while Ormas soils cover 15% and Boyer soils are present in 14% of the soil association. Kosciusko soils are nearly level soils found on moderately sloping areas. Sink holes are common within the sandy loam, sandy clay loam, and gravelly loam Kosciusko soils. Ormas

soils cover moderately sloping areas and typically have a loamy sand or sandy clay loam texture. Boyer soils are generally found in steeper areas and have a of loamy sand or sandy loam texture.

Dredging and straightening of the stream channel and the immediate watershed land use negatively impact Palfreyman Drain. Palfreyman Drain was last cleaned in 1986 (Larry Gilbert, personal communication). At that time, instream work consisted of removing accumulated sediment from the stream channel to maintain adequate drainage of the subwatershed. Since that time, channel erosion and streambank and bed scour have created unstable conditions within the stream. Palfreyman Drain's streambanks are relatively steep measuring 2:1 or 1:1 (horizontal:vertical) along much of the project site. Streambanks measure 7 to 14 feet in height.

The riparian area is very narrow along the length of Palfreyman Drain due to adjacent land use and narrow, steeply-sloped streambanks. Agricultural fields are cultivated to the stream's edge from County Road 200 West south to the wetland immediately north of Interstate-69. Fescue and reed canary grass vegetate the streambanks along a majority of this portion of the drain. South of Interstate-69, a narrow, sparse band of oaks, maples, sycamores, and shrubs cover the southwestern streambank providing a buffer from the adjacent residential areas. Agricultural fields cultivated to the stream's edge border Palfreyman Drain's northeastern streambank from Interstate-69 south and east to the southern bend in the stream. As with the northern agricultural area, fescue and reed canary grass vegetate the northeastern streambank along this segment of the stream channel. Local Soil and Water Conservation District (SWCD) personnel plan to approach landowners along the length of Palfreyman Drain to discuss the use of Conservation Reserve Programs (CRP). Potential CRP options include the installation of filter strips, grade stabilization structures or water and sediment control basins (WASCOBs) along the edge of the stream, and the use of conservation tillage. These items are beyond the scope of this feasibility study and therefore, will not be addressed further in this document. Forest and scrub shrub uplands border the stream from the southern bend south to Harcourt Road (County Road 100 North). The southernmost portion of Palfreyman Drain located adjacent to and south of Harcourt Road is contained entirely within residential and commercial areas.

The conversion of natural landscapes to urban (residential and commercial) and agricultural land uses results in the removal of vegetation and, in the case of urban land, the creation of more impermeable surfaces (Basnyat et al., 2000). These impermeable surfaces coupled with the lack of vegetation to intercept precipitation and runoff results in a decline in the volume of water infiltrating the soil (Corbett et al., 1997). The lack of infiltration causes stormwater, which normally would move through the soil as groundwater or subsurface flow, to move as overland or surface flow. Eventually, overland flow enters the stream channel. Ultimately, the increase in impervious surfaces, lack of emergent vegetation, and absence of stormwater infiltration results in more surface water reaching the stream at a faster rate, thereby creating a flashy stream system characterized by greater variability in water level fluctuations (Tourbier, 1994).

Flashy streams, such as Palfreyman Drain, are often subjected to greater peak flows as a result of the volume and velocity of surface runoff (Ferguson and Deak, 1994). Rapidly fluctuating water levels and high flow volumes increase the erosive force of the water resulting in streambank and bed erosion. As water erodes material at the toe of the slope, the streambanks become unstable. This results in the sloughing of bank material. This material is then carried downstream and

deposited in areas of lower velocity. The erosion and deposition of instream material continues until sediments and sediment-attached nutrients eventually reach Crooked Lake.

The processes of erosion and deposition of bank material continues until the stream reaches a stable condition. In the case of Palfreyman Drain, the relatively steep gradient, sandy soils, and steep streambanks limit the ability of the stream to create stable conditions. Nearly continuous lateral channel migration, bed scour, and bank sloughing results from the unstable conditions present in Palfreyman Drain.

Several critical erosion areas were identified during field inventories of Palfreyman Drain. (Photographs of many of these areas are included in Appendix A.) The most critical areas of bank erosion and sloughing occur upstream of Interstate-69; however, bank erosion and sloughing also occurs in isolated locations along the stream channel downstream of Interstate-69. Multiple options to reduce streambank and bed erosion and bank sloughing and to control the transport of sediment and sediment-attached nutrients to Crooked Lake were identified. Possible solutions include stabilization with riprap (hard-armoring) along the length of the project site, installation of minor repairs along the highest priority areas, reconstruction of the existing stream channel to handle current and future potential flows, and no action.

Hard-armoring, using either riprap or glacial stone, along the entire length of the open stream channel (10,500 lineal feet) would curtail stream erosion along Palfreyman Drain. However, the use of riprap along the entire channel would not improve the aesthetic or overall habitat value of the stream. Additionally, hard-armoring would be expensive costing approximately $75 per lineal foot. In total, this results in a cost of more than $1.5 million. These issues make hard armoring the length of the stream infeasible for addressing erosional issues along Palfreyman Drain.

Installing minor corrective actions, like riprap installation or minor streambank regrading, along the most severe areas will likely provide only short term benefit. Each of these actions would improve or correct erosional issues along severe areas; however, correcting only these areas will likely results in the creation of new problem areas along Palfreyman Drain. This option would require annual maintenance activities an the installation of spot treatments throughout the length of the stream channel. In the long-term, the entire length of the channel would likely be addressed but at a more costly approach than that described above. This option could provide short term fixes, but should not be looked upon as a long-term solution. Therefore, this option is not recommended.

Plans and designs for the reconstruction of Palfreyman Drain should include an assessment of current and future land uses affecting runoff; an evaluation of present ditch capacity and instream velocity based on existing cross-sections and profiles completed for the last ditch cleaning; an investigation of the desired storm protection for the streambank; recommendation of methods and designs for stream reconstruction to handle the future volume and velocity of runoff; and final proposed construction specific designs. Potential options to be considered when redesigning the stream channel include, but are not limited to, the following: grade control structures or check dams, channel widening, in-line detention, resloping streambanks, and a two-stage channel design. All of the options should be considered when the stream channel is redesigned.

The final alternative is taking no action. Under this option, the streambanks will continue to erode and bank sloughing will continue along the length of the drain. This option will not result in any improvements of instream water quality nor will the delivery of sediment and sediment-attached pollutants be reduced.

The best alternative to address streambank and bed erosion in Palfreyman Drain is to redesign stream channel to more adequately handle water volumes and velocities from the stream's watershed using future runoff conditions. Ultimately, a properly sized stream channel will improve and maintain long-term channel stability. Because fixing only small areas of erosion will only supply a quick fix with different portions of the stream channel being addressed on an annual basis, redesigning the stream channel was selected as the best option for reducing sediment and sediment-attached nutrient loading to Crooked Lake. In summary, two alternatives to treating the erosion along Palfreyman Drain are feasible. The first, treating the erosion by armoring the existing channel banks is expensive and ecologically destructive. The second approach, reconstructing the stream channel to adequately handle expected water volumes and velocities from the watershed, is a long-term approach that may cost more up front, but will have much lower long-term costs. Therefore, a project that involves a design study is recommended before any reconstruction or bank treatment occurs.

### 3.4.2 Easement and Land Availability Determination

Palfreyman Drain is a legal drain and is under the jurisdiction of the Steuben County Drainage Board. Any activities to occur within the drainage board right-of-way must be approved by the drainage board. Landowners adjacent to the project site were not contacted during the completion of this study. However, their input and participation will be necessary for the completion of the assessment, redesign, and reconstruction of the Palfreyman Drain stream channel. The proposed project will be completed with the input of the drainage board and the Steuben County Surveyor. The Steuben County Surveyor signed a letter supporting the project (Appendix B).

### 3.4.3 Preliminary Design and Conceptual Drawings

Preliminary designs and conceptual drawings for this project were not created during this feasibility study. Because the long-term solution for stabilizing the streambank and bed, curtailing channel erosion, and reducing the flow of sediment and sediment-attached pollutants into Crooked Lake involves assessing the current and future conditions of the Palfreyman Drain subwatershed and redesigning the entire channel, neither conceptual drawings nor preliminary designs were created. All necessary surveys, assessments, and plans should be completed during the channel redesign project.

### 3.4.4 Permit Requirements

Permits will be required for any construction that occurs as a result of redesigning the stream channel. As Palfreyman Drain is a legal drain, any activities that occur within or adjacent to Palfreyman Drain require approval from the Steuben County Drainage Board. An IDNR construction in a floodway permit is necessary for work in or along this channel since the drainage area is greater than one square mile. A Section 401 Water Quality Certification from the

IDEM and a Section 404 Permit from the Corps are required because Palfreyman Drain is a "waters of the United States."

### 3.4.5 Wetland Functional Assessment

The general location and extent of one wetland was mapped during a field survey conducted on July 20, 2004. Figure 19 shows the approximate location of this wetland area. The wetland is location north of Interstate-69 and lies both east and west of Palfreyman Drain. The wetland is currently utilized as a sediment trap. The sediment trap was constructed in 1999. Dogwood (*Cornus* species), cottonwood (*Populus deltoides*), American elm (*Ulmus americanus*), sedges (*Carex* species), jewelweed (*Impatiens* species), and asters (*Aster* species) vegetate the wetland. The wetland currently serves as good wildlife habitat, provides floodwater storage, and supplies groundwater recharge. None of these will be limited or inhibited by the redesigned channel.

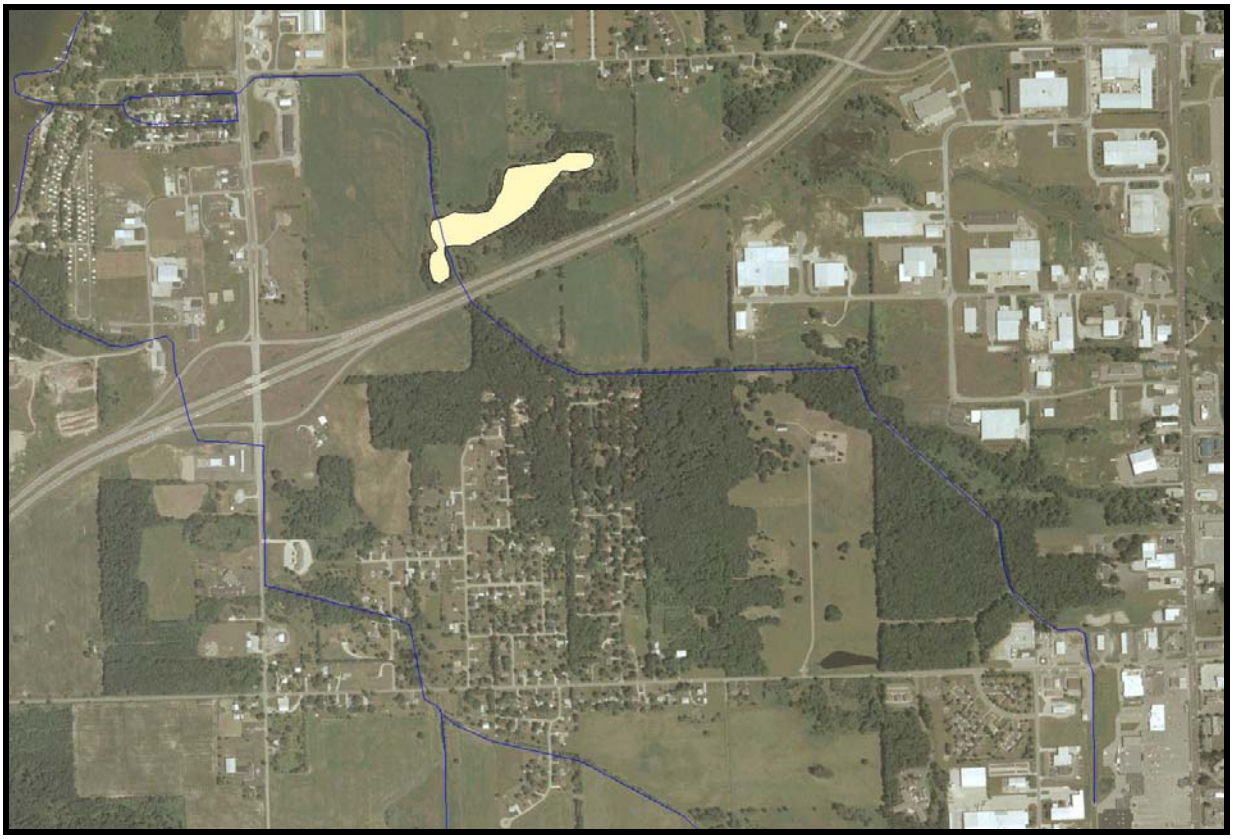

**Figure 19. Approximate wetland boundary within the Palfreyman Drain channel redesign project site.**

### 3.4.6 Biological and Habitat Integrity Survey

The biological and habitat integrity survey results for Palfreyman Drain are detailed in Section 3.2.6 and are not repeated here.

### 3.4.7 Environmental Impact Assessment

The environmental impact of reconstructing the stream channel cannot be completely quantified at this time. However, all relevant environmental considerations should be taken into account

during the assessment and design phase of the project. The new channel design will make all efforts to avoid impacts to wetlands within or adjacent to the project corridor. No endangered, threatened, or rare species are listed in the IDNR Natural Heritage Database for the Palfreyman Drain corridor. Likewise, no endangered, threatened, or rare flora or fauna were located during any of the on-site visits. The reconstructed channel should account for future increases in stream flow and bed load; therefore, all efforts should be made to reduce the transport of sediment and sediment-attached nutrients downstream to Crooked Lake. A reconstruction project should result in better instream habitat and water quality leading to higher quality aquatic biota within Palfreyman Drain.

### 3.4.8 Unusual Physical and Social Costs

There are no unusual physical or social costs associated with the redesign of Palfreyman Drain. Specific physical and social costs may be attributed to the actual construction of the project. Potential physical and social costs include: the loss of agricultural row crop acreage within the drainage board right-of-way and removal, transportation, and disposal of sand and other bank material. During the design phase, all efforts should be made to reduce physical and social costs associated with this project.

### 3.4.9 Opinions of Probable Cost

The opinion of probable cost for design is $45,000 for completing the necessary surveys to adequately redesign Palfreyman Drain's channel (Table 10). A cost estimate for actual reconstruction cannot be calculated until the design is complete.

**Table 10. Opinion of probable cost for the proposed redesign of Palfreyman Drain.**

| Item | Cost | Unit | Number | Total |
|---|---|---|---|---|
| Surveys and watershed modeling | $6,000 | each | 1 | $6,000 |
| Channel design | $11,400 | each | 1 | $11,400 |
| Project meetings | $2,600 | each | 1 | $2,600 |
| Report completion | $4,000 | each | 1 | $4,000 |
| Quality assurance/Quality control | $2,000 | each | 1 | $2,000 |
| Permitting | $6,000 | each | 1 | $6,000 |
| Landowner agreement | $4,000 | each | 1 | $4,000 |
| Contingency | 25% | each | 1 | $9,000 |
| **Total** | | | | **$45,000** |

The recommended project timeline is based on grant funding cycles. It is recommended that the CLA apply for design funding through the LARE program in early 2005, contract design services in late 2005 after grant award, and design the project in the winter of 2005/2006. Construction funding sources should be considered after the design is completed.

### 3.4.10 Project Justification and Estimation of Impact

Streambank erosion has historically been identified as an important contributor to net sediment loading at Palfreyman Drain (William Hill and Associates, 1989). Streambank erosion is a natural process that occurs under normal conditions in a stream. However, anthropogenic (human induced) factors can negatively impact the stream system causing fluctuation in the amplitude of stream flows. Conversion of Palfreyman Drain's watershed from forest and prairie to

agricultural, then residential and commercial, land use increased the volume and velocity of water moving through Palfreyman Drain. In its current state, Palfreyman Drain cannot handle the volume of water moving through the channel. During periods of high flow, such as storm events, rapidly moving water carries bank material away from the toe of the streambank. As more and more bank material is removed from the base of the streambanks, the side slopes become steeper forming banks like those present along much of Palfreyman Drain. Roseboom and White (1990) and Isenhart et al. (1997) attributed >50% of the sediment load carried by small streams in the Midwest to channel erosion.

It is likely that a large percentage of sediment present in Palfreyman Drain originated from bank material. As sloughed material is removed, the process repeats itself carrying sediment from one location in the stream and depositing sediment in another location further downstream. The sandy nature of Palfreyman Drain only exacerbates the streambank erosion and sloughing that occurs within the drain's channel. Eventually sediment and sediment-attached nutrients transported within Palfreyman Drain reach Crooked Lake, where they are deposited at the mouth of the stream channel.

The goal of reconstructing the stream channel is to improve instream stability. This will be accomplished through a number of mechanisms which include: regulating the flashy nature of the stream system; reducing the variability of instream flows; and minimizing streambank and bed erosion, bank sloughing, and channel scour. All of these will improve stream stability resulting in better instream habitat and higher water quality.

## 3.5 Wetland restoration, Carpenter Drain subwatershed

### 3.5.1 Site Description and Alternatives

Eight potential wetland restoration sites were identified during field surveys and utilizing aerial photographs of the watershed. The presence of hydric soils at each of the potential wetland restoration sites was confirmed using the Steuben County Soil Survey (Farmer, 1981) prior to selecting the site. These sites are concentrated in the Carpenter Drain subwatershed; however, one site is located in the Loon Lake tributary subwatershed and one site is located in the Palfreyman Drain subwatershed (Figure 1). A majority of the potential wetland restoration sites are located within predominantly row crop agriculture and pasture land. The Palfreyman Drain wetland restoration site is located within predominantly forested land, while two of the Carpenter Drain wetland restoration sites are located in more urban areas adjacent to County Road 200 West near Peachtree Plaza. Figure 20 displays the approximate wetland restoration boundaries for each of the eight potential sites.

All potential wetland restoration sites were investigated for their restoration potential. JFNew biologists walked each site to determine if the site was restorable and to identify any possible limitations for restoration. The drainage basin of each potential site was also evaluated to assist in the determination of the potential water quality improvement associated with each potential wetland restoration. Table 11 details the potential for restoration and limitations for each of the eight identified sites. Of the identified wetlands, Wetlands 4 and 6 provide the best benefit and highest potential for wetland restoration. Although this property is currently for sale, the farm management agency representative indicated that wetland restoration information would be

provided to the new landowner upon sale of the property. The Crooked Lake Association should continue to work with the farm management agency and the new landowner to pursue wetland restoration opportunities on this property. However, at this time all of the potential wetland restoration projects are deemed infeasible.

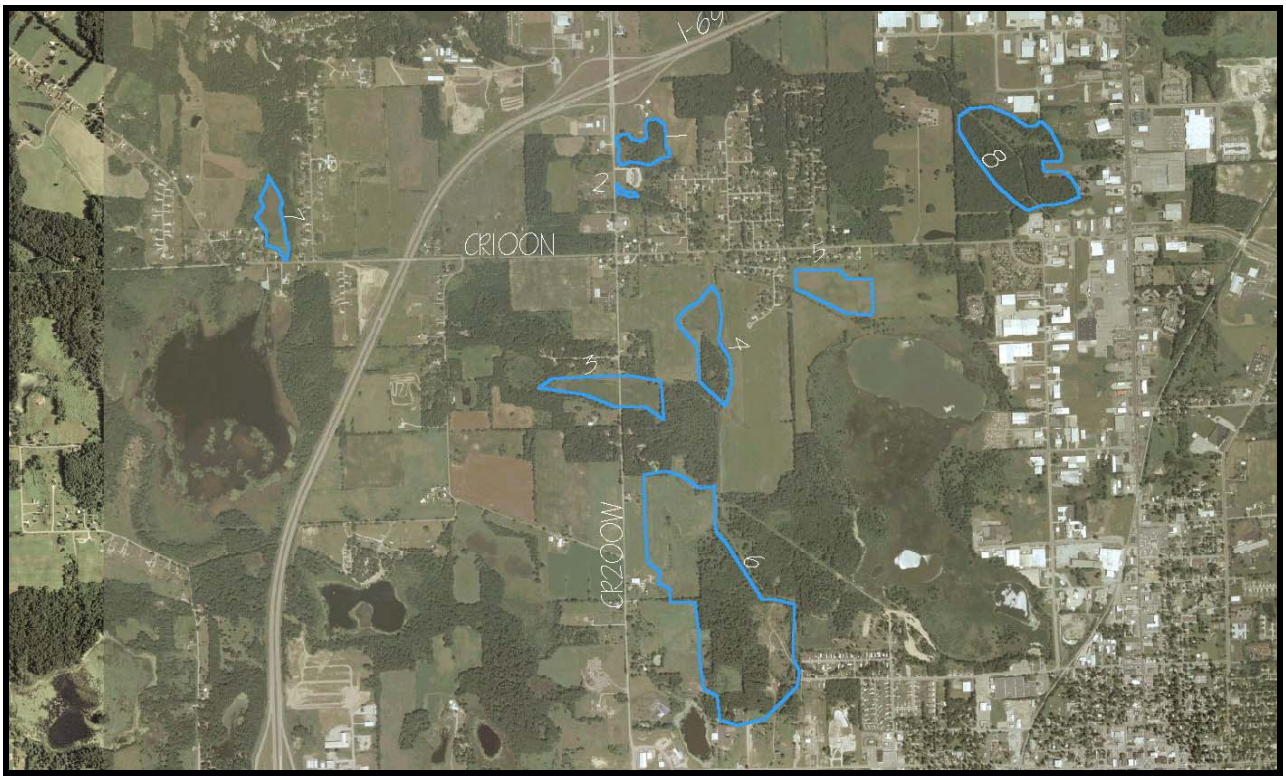


**Figure 20. Potential wetland restoration sites within Crooked Lake's watershed.**

**Table 11. Potential for restoration of the identified wetlands.**

| Wetland | Restoration Value | Obstacles to Restoration |
|---|---|---|
| 1 | Limited: Provides little benefit to Crooked Lake (watershed is forested/grass) | Lot for sale (commercial) |
| 2 | Limited: Pollutant removal impact would be minimal | Restorable area is too small for watershed area |
| 3 | Limited: Provides little benefit to Crooked Lake (watershed is small and is forested/grass) | Fenced pasture recently installed |
| 4 | Recommended: Good potential for runoff filtration from highly erosive cropland | Property is currently for sale |
| 5 | Limited: Provides little benefit to Crooked Lake (upstream wetlands filter sediment and nutrients) | Property is currently for sale |
| 6 | Recommended: Multiple individual restoration sites; Good potential for runoff filtration from highly erosive cropland | Property is currently for sale |
| 7 | Little: Cost outweighs benefit to Crooked Lake (watershed is in permanent grass cover or wetland) | Not recommended at this time |
| 8 | Little: Cost outweighs benefit to Crooked Lake | Restoration would likely |

| | | |
|---|---|---|
| | | affect flow through Palfreyman Drain |

### 3.5.2 Landowner Agreements
JFNew contacted the farm management agency that currently manages the property where Wetlands 4 and 6 are located. Because the property is currently for sale, a specific wetland restoration project is not being pursued at this time. Therefore, landowner agreements are not being pursued.

### 3.5.3 Preliminary Design and Conceptual Drawings
Preliminary designs and conceptual drawings have not been developed. If and when the property is sold, the CLA or their designated representative should approach the new landowner regarding wetland restoration potential. If the landowner decides to restore part of their property to wetland habitat, then preliminary designs and conceptual drawings should be developed.

### 3.5.4 Permit Requirements
No permits are required at this time.

### 3.5.5 Wetland Functional Assessment
Wetland functional assessments were not conducted for this project area because a specific wetland restoration project is not being pursued at this time.

### 3.5.6 Biological and Habitat Integrity Survey
A biological and habitat integrity survey was not conducted for this project area because a specific wetland restoration project is not being pursued at this time.

### 3.5.7 Environmental Impact Assessment
An environmental impact assessment was not conducted for this project area because a specific wetland restoration project is not being pursued at this time.

### 3.5.8 Unusual Physical and Social Costs
The loss of productive farmland is the only potential unusual social cost associated with the potential wetland restoration projects. However, since a project is not being pursued, there are no unusual physical or social costs associated with this project at this time.

### 3.5.9 Opinions of Probable Cost
Probable costs associated with wetland restoration were not determined during the course of this study. If the new landowner is interested in pursuing wetland restoration opportunities, it is recommended that they do so with funding from the Wetland Reserve Program.

## 4.0 LITERATURE CITED

Atlanta Regional Commission. 2004. Georgia Stormwater Management Manual. Structural Stormwater Control, Volume 2 (Technical Handbook). Atlanta, Georgia.

Bannerman, R., R. Dodds, D. Owens, and P. Hughes. 1992. Sources of Pollutants in Wisconsin Stormwater. Wisconsin Department of Natural Resources, Madison, Wisconsin.

Barbour, M.T., J. Gerritsen, B.D. Snyder, and J.B. Stribling. 1999. Rapid Bioassessment Protocols for Use in Wadeable Streams and Rivers: Periphyton, Benthic Macroinvertebrates, and Fish. 2nd Edition. U.S. Environmental Protection Agency, Office of Water. Washington, D.C. EPA 841-B99-002.

Baskins, Forster and Company. 1876. Indiana Counties in 1876. Indiana Historical Society, Indianapolis, Indiana.

Basnyat, P., L.D. teeter, B.G. Lackaby, and K.M. Flynn. 2000. The use of remote sensing and GIS in watershed level analyses of non-point source pollution problems. For. Ecol. Manage. 128:65-73.

Corbett, C.W., M. Wahl, D.E. Porter, D. Edwards, and C. Moise. 1997. Nonpoint source of runoff modeling: A comparison of a forested watershed and an urban watershed in South Carolina coast. J. Exp. Marine Biol. Ecol. 213: 133-149.

Correll, David L. 1998. The role of phosphorus in the eutrophication of receiving waters: a review. J. Environ. Qual., 27(2):261-266.

Cwalinski, T.A. 1999. Assessment of Advanced walleye Fingerling Stockings at Northern Indiana Lakes. Work Plan Number 200008. Department of Natural Resources, Indianapolis, Indiana.

DeLorme. 1998. Indiana Atlas and Gazetteer.

Farmer, D. L. 1981. Soil Survey of Steuben County, Indiana. USDA Soil Conservation Service and Purdue Agricultural Experiment Station.

Ferguson, B.K. and T. Deak. 1994. Role of urban storm-flow volume on local drainage problems. J. water Res. Planning and Management. 120:523-530.

Hippensteel, P. 1988. Unpublished data files, 1973-1987. Tri-State University, Angola, Indiana.

Homoya, M.A., B.D. Abrell, J.R. Aldrich, and T.W. Post. 1985. The natural regions of Indiana. Indiana Academy of Science. Vol. 94. Indiana Natural Heritage Program. Indiana Department of Natural Resources, Indianapolis, Indiana.

Hudson, G. 1967. Lake Survey Report Crooked Lake, Steuben County. Department of Natural Resources, Indianapolis, Indiana.

Indiana Department of Environmental Management. 1986. Indiana Lake Classification System and Management Plan. Indianapolis, Indiana.

Indiana Department of Environmental Management. Clean Lakes Program. 1992, 1997, 2002.

Isenhart, T.M., R.C. Schultz, and J.P. Colletti. 1997. Watershed restoration and agricultural practices in the Midwest: Bear Creek of Iowa. In: Williams, J.E., C.A. Wood, and M.P. Dombeck (eds.) Watershed Restoration Principles and Practices. American Fisheries Society, Bethesda, Maryland, p. 318-334.

JFNew. 2003. Crooked Lake Monitoring Study. Looseleaf publication. Walkerton, Indiana.

Karr, J.R. and D.R. Dudley. 1981. Ecological perspective on water quality goals. Environmental Management. 5:55-68.

Koza, L.A. 2002. Crooked Lake, Steuben County Fish Management Report. Department of Natural Resources, Indianapolis, Indiana.

Ledet, N. 1988. Lake Survey Report, Crooked Lake. Indiana Department of Natural Resources, Division of Fish and Wildlife, Indianapolis, Indiana.

McCafferty, W.P. 1981. Aquatic Entomology: The Fisherman's and Ecologists' Illustrated Guide to Insects and Their Relatives. Jones and Bartlett Publishers: Sudbury, Massachusetts.

Michigan Department of Environmental Quality. 2004. Infiltration BMPs. Michigan Department of Environmental Quality, Lansing, Michigan.

Ohio EPA. 1999. Association between nutrients, habitat, and the aquatic biota in Ohio rivers and streams. Ohio EPA Technical Bulletin MAS/1999-1-1, Columbus, Ohio.

Omernik, J.M. and A.L. Gallant. 1988. Ecoregions of the upper Midwest states. USEPA, ERL. Corvallis, Oregon. EPA/600/3-88/037.

Peterson, R. 1973. Lake Survey Report, Crooked Lake, Steuben County. Department of Natural Resources, Indianapolis, Indiana.

Peterson, R. 1978. Lake Survey Report, Crooked Lake, Steuben County. Department of Natural Resources, Indianapolis, Indiana.

Purdue University. 1980. Trophic Status of Fifteen Indiana Lakes in 1977. Department of Forestry and Natural Resources, West Lafayette, Indiana.

Rain Gardens of West Michigan. 2004. Qualities and Benefits. [web site] Rain Gardens of West Michigan. [Accessed October 4, 2004]

Rankin, E.T. 1989. The qualitative habitat evaluation index (QHEI): rationale, methods, and application. Division of Water Quality Planning and Assessment, Columbus, Ohio.

Rankin, E.T. 1995. Habitat indices in water resource quality assessment, in W.S. Davis and T. Simon (eds.). Biological Assessment and Criteria: Tools for Risk-based Planning and Decision Making. CRC Press/Lewis Publishers, Ann Arbor, Michigan.

Roseboom, D.P. and W. White. 1990. The Court Creek restoration project: erosion control technology in transition. Pages 25-40 in Proceedings of XXI conference of the International Erosion Control Association. IECA, Steamboat Springs, Colorado.

Sharpley, A.N., W.J. Gburek, G.Folmar, and H.B. Pionke. 1999. Sources of phosphorus exported from an agricultural watershed in Pennsylvania. Ag. Water Manage. 41:77-89.

Simon, T.P. 1997. Development of Index of Biotic Integrity expectations for the ecoregions of Indiana. III. Northern Indiana Till Plain. USEPA, Region V, Water Division, Watershed and Non-Point Source Branch. Chicago, Illinois. EPA905/R-96/002.

Steuer, J. W. Selbig, N. Hornewer, and J. Prey. 1997. Sources of Contamination in Urban Basin in Marquette, Michigan and an Analysis of Concentrations, Loads, and Data Quality. USGS Water Resources Investigation Report 97-4242. Wisconsin Department of Natural Resources, Madison, Wisconsin and USEPA, Washington, DC.

Striffler, W.D. 1964. Sediment, streamflow, and land use relationships in northern lower Michigan. U.S. Forest Service, Lake States Forest Experiment Station, St. Paul, Minnesota, and Michigan Department of Conservation, Research Paper LS-16, Ann Arbor, Michigan.

Tourbier, J.T. 1994. Open space through stormwater management: Helping to structure growth on the urban fringe. J. Soil water Cons. 49: 14-22.

U.S. Environmental Protection Agency. 1976. National Eutrophication Survey: Crooked Lake, Steuben County. Working Paper Number 325.

U.S. Environmental Protection Agency. 1981. Environmental Impact Statement: Alternative Waste Treatment Systems for Rural Lake Projects, Case Study Number 4, Steuben Lakes Regional Waste District, Steuben County, Indiana.

U.S. Environmental Protection Agency. 1999a. Storm Water Technology Fact Sheet. Vegetated Swales. USEPA, Office of Water, Washington, D.C. EPA 832-F-99-006.

U.S. Environmental Protection Agency.1999b. Storm Water Technology Fact Sheet Infiltration Trench. USEPA, Office of Water, Washington, D.C. EPA 832-F-99-019.

University of Wisconsin Extension. 2003. Rain Gardens: A How-to Manual for Homeowners. UWEX Publication GWQ037. Wisconsin Department of Natural Resources, DNR Publication PUB-WT-776 2003, Madison, Wisconsin.

Waschbusch, R., W. Selbig, and R. Bannerman. 2000. Sources of Phosphorus in Stormwater and Street Dirt from Two Urban Residential Basins in Madison, Wisconsin, 1994-1995. Proceedings from National Conference of Tools for Urban Water Resource management and Protection, Chicago, Illinois.

Waters, T.F. 1995. Sediment in streams: sources, biological effects, and control. American Fisheries Society Monograph 7.

William W. Hill and Associates. 1991. Crooked Lake, Watersheds of Carpenter and Palfreyman Ditches Feasibility Study, Lake Enhancement Program, Indiana Department of Natural Resources, Indianapolis, Indiana.

Winogradoff, D.A. 2002. Prince George's County Bioretention Manual. Programs and Planning Division, Department of Environmental Resources, Prince George's County, Maryland.

# APPENDICES

## CROOKED LAKE ENGINEERING FEASIBLITY STUDY
## STEUBEN COUNTY, INDIANA

# APPENDIX A:

# PROJECT SITE PHOTOGRAPHS

# CROOKED LAKE ENGINEERING FEASIBLITY STUDY
# STEUBEN COUNTY, INDIANA

**AREA 1:**

**Bank Erosion Photographs along the Mainstem of Carpenter Drain**
**Crooked Lake Engineering Feasibility Report**
**Carpenter Drain Bank Stabilization Project**
**Steuben County, Indiana**

JFNA# 03-01-10/01

**AREA 2:**

**Bank Erosion Photographs along the Mainstem of Carpenter Drain**
**Crooked Lake Engineering Feasibility Report**
**Carpenter Drain Bank Stabilization Project**
**Steuben County, Indiana**

JFNA# 03-01-10/01

**AREA 3:**

**Bank Erosion Photographs along the Mainstem of Carpenter Drain**
**Crooked Lake Engineering Feasibility Report**
**Carpenter Drain Bank Stabilization Project**
**Steuben County, Indiana**

**Infiltration Trench Location**

**Debris Removal**

**Representative Photographs**
**Crooked Lake Engineering Feasibility Report**
**Palfreyman Drain-Stormwater and Erosion Control Project**
**Steuben County, Indiana**

**Erosion along Northern Bank of Palfreyman Drain**

**Erosion along Northern Bank of Palfreyman Drain**

**Representative Photographs**
**Crooked Lake Engineering Feasibility Report**
**Palfreyman Drain-Stormwater and Erosion Control Project**
**Steuben County, Indiana**

**Vegetated Swale: Existing Pipe and Associated Erosion**

**South End of Proposed Vegetated Swale**

**Representative Photographs**
**Crooked Lake Engineering Feasibility Report**
**Palfreyman Drain-Stormwater and Erosion Control Project**
**Steuben County, Indiana**

**Proposed Rain Garden (east) Installation Location from the Top of the Hill (July 2004)**

**Proposed Rain Garden (east) Installation Location from the Bottom of the Hill (January 2005)**

**Representative Photographs**
**Crooked Lake Engineering Feasibility Report**
**4-H Park, Stormwater Treatment Project**
**Steuben County, Indiana**

JFNA# 03-01-10/01

**Gravel Driveway and Washout which Will Drain to East Rain Garden**

**Example of Gully Erosion Adjacent to Gravel Driveway**

**Representative Photographs**
**Crooked Lake Engineering Feasibility Report**
**4-H Park, Stormwater Treatment**
**Steuben County, Indiana**

**Streambank Erosion along Palfreyman Drain**

**Streambank Erosion along Palfreyman Drain**

**Representative Photographs**
**Crooked Lake Engineering Feasibility Report**
**Palfreyman Drain-Channel Redesign**
**Steuben County, Indiana**

JFNA# 03-01-10/01

**Streambank Erosion along Palfreyman Drain**

**Streambank Erosion along Palfreyman Drain**

**Representative Photographs**
**Crooked Lake Engineering Feasibility Report**
**Palfreyman Drain-Channel Redesign**
**Steuben County, Indiana**

**Streambank Erosion along Palfreyman Drain**

**Streambank Erosion along Palfreyman Drain**

**Representative Photographs**
**Crooked Lake Engineering Feasibility Report**
**Palfreyman Drain-Channel Redesign**
**Steuben County, Indiana**

JFNA# 03-01-10/01

# APPENDIX B:

# LANDOWNER COMMUNICATION

# CROOKED LAKE ENGINEERING FEASIBLITY STUDY
# STEUBEN COUNTY, INDIANA

JFNew
Wise Growth Through Stewardship

708 Roosevelt Road
Walkerton, Indiana 46574
Phone: 574-586-3400 ext. 341
Fax: 574-586-3446

Sara Peel
Aquatic Ecologist
email: speel@jfnew.com

Corporate Office:
Walkerton, Indiana

Crete, Illinois

Indianapolis, Indiana

Grand Haven, Michigan

Cincinnati, Ohio

Native Plant Nursery:
Walkerton, Indiana

**www.jfnew.com**

13 January 2004

Larry Gilbert
Steuben County Surveyor
317 S. Wayne Street
Angola, Indiana 46703

Steuben County Commissioners
317 S. Wayne Street
Angola, Indiana 46703

Dear Sirs:

JFNew is working with the Crooked Lake Association (CLA) to complete an engineering feasibility study. The purpose of the project is to address the feasibility of implementing erosion control projects in the Crooked Lake Watershed in order to slow loading of sediment and associated nutrients that can impair water quality in the lake.

We conducted a site visit earlier this month to address the portion of Carpenter Drain which flows through the Steuben County Park in greater detail. Our findings indicate that an erosion control project is physically possible and could slow erosion processes within the channel of Carpenter Drain and reduce sediment and sediment-attached nutrient loading to Crooked Lake. We identified three smaller areas of erosion in the park. Each of these sections would benefit from streambank stabilization and are shown on the enclosed map and photographs.

We are proposing the use of bioengineering techniques to stabilize the stream channel. Bioengineering is desirable when maintenance of the natural habitat and aesthetics is desired as it is in this case. Our conceptual design includes the installation of soil encapsulated lifts along approximately 200 feet of the stream at the three sites mentioned above. Soil encapsulated lifts are typically constructed by installing a toe of large diameter fieldstone and wrapping coir fabric around a soil lift that is keyed into the bank. Grasses and woody vegetation are then used to stabilize the lift. Bare-root shrubs will be incorporated into at least the first layer of the lift to establish long-term scour protection and provide lateral stability. The fabric typically lasts for up to 10 years, allowing enough time to establish permanent vegetation cover for erosion control. The enclosed schematic details a typical soil-encapsulated lift structure.

If you, the Steuben County Commissioners, and the regulatory agencies approve of the concept, the Crooked Lake Association is hoping to apply for an Indiana Department of Natural Resources grant in February 2004 with design and construction to begin in late 2004 or early 2005. Your input

would definitely be sought when it comes to the actual design work. If you approve of the conceptual design for steambank stabilization on Carpenter Drain, please sign below and return in the included postage-paid envelope.

Please contact me directly should you have any questions pertaining to this project and its scope at (574) 586-3400 or speel@jfnew.com. We are more than happy to address any concerns you might have. Thank you for helping us assist the Crooked Lake Association in their goals to reduce pollutant loading into the Crooked Lake.

Thank you for your consideration.

Sincerely,

Sara Peel
Project Manager

cc. Keith Hoskins, Crooked Lake Associations
JFNew file 03-01-10/01

_____

I approve of the conceptual design for channel stabilization of Carpenter Drain and understand that the Crooked Lake Association and/or its contractor will contact me again during the design portion before construction is initiated.

19 April 2004

JFNew
Wise Growth Through Stewardship

708 Roosevelt Road
Walkerton, Indiana 46574
Phone: 574-586-3400 ext. 341
Fax: 574-586-3446

Sara Peel
Aquatic Ecologist
email: speel@jfnew.com

Corporate Office:
Walkerton, Indiana

Crete, Illinois

Indianapolis, Indiana

Grand Haven, Michigan

Cincinnati, Ohio

Native Plant Nursery:
Walkerton, Indiana

**www.jfnew.com**

Jim Wyatt
Steuben County Highway Department
1900 N 200 W
Angola, IN 46703

Mayo Sanders
Steuben County Commissioners
317 S. Wayne St.
Angola, IN 46703

Dear Mr. Wyatt and Mr. Sanders:

JFNew is working with the Crooked Lake Association (CLA) to complete an engineering feasibility study. The purpose of the project is to address the feasibility of implementing erosion control projects in the Crooked Lake Watershed in order to slow loading of sediment and associated nutrients that can impair water quality in the lake.

In early April, we conducted a site visit to address the portion of Palfreyman Drain which flows along County Road 100 North adjacent to the highway department facility. Our findings indicate that a project to reduce erosion and pollution entering Palfreyman Drain is feasible. We identified three techniques to address stormwater and erosion issues along this reach of Palfreyman Drain. These techniques include the creation of an infiltration trench between Palfreyman Drain and County Road 100 North, the placement of stone along the length of the northern stream bank, and the installation of a vegetated swale in place of the drain located on the highway department property. Conceptual drawings of the techniques and each of the areas where these techniques are recommended are shown on the enclosed figures and photographs.

If you agree with this concept plan for the County Highway property please sign below and return a copy to me in the envelope provided. Signing this supports our efforts to obtain additional grant money for final design and construction funding. We welcome any suggested changes you might have at this time, so please feel free to write comments on the draft plan and return them to me. Please call me if you have any immediate concerns or questions. Thank you for your consideration.

Please contact me directly should you have any questions pertaining to this project and its scope at (574) 586-3400 or speel@jfnew.com. We are more than happy to address any concerns you might have. Thank you for helping us assist the Crooked Lake Association in their goals to reduce pollutant loading into the Crooked Lake.

Thank you for your consideration.
Sincerely,

Sara Peel
Project Manager

I agree with the above concept plan.

cc. Keith Hoskins, Crooked Lake Association
Larry Gilbert, Steuben County Surveyor
JFNew file 03-01-10/01

JFNew
Wise Growth Through Stewardship

708 Roosevelt Road
Walkerton, Indiana 46574
Phone: 574-586-3400 ext. 341
Fax: 574-586-3446

Sara Peel
Aquatic Ecologist
email: speel@jfnew.com

Corporate Office:
Walkerton, Indiana

Crete, Illinois

Indianapolis, Indiana

Grand Haven, Michigan

Cincinnati, Ohio

Native Plant Nursery:
Walkerton, Indiana

**www.jfnew.com**

11 August 2004

Steuben County Commissioners
317 S. Wayne Street
Angola, Indiana 46703

Dear Sirs:

JFNew is working with the Crooked Lake Association (CLA) to complete an engineering feasibility study. The purpose of the project is to address the feasibility of implementing erosion control projects in the Crooked Lake Watershed in order to slow loading of sediment and associated nutrients that can impair water quality in the lake. We conducted a site visit earlier this month to address stormwater runoff from the Steuben County 4-H park to Crooked Lake. Our findings indicate that the installation of several inexpensive measures could slow stormwater runoff from the park and reduce erosion of the gravel roads thereby reducing sediment and sediment-attached nutrient loading to Crooked Lake.

We are proposing the use of a series of deflector logs and gravel-filled drainage channels to direct stormwater runoff off of the roads and into a rain garden. Water bars installed across the gravel roadways would direct water away from the road into a gravel-lined drainage swale. The drainage swale would then carry water away from the road toward the rain garden, a bowl-shaped garden designed to absorb and filter stormwater. A rain garden resembles a typical flower garden planted with perennial, deep-rooted native plants. The garden will provide landscaping and wildlife habitat while filtering stormwater runoff from the west end of the 4-H park. The rain garden will require little maintenance or upkeep, will reduce lawn care cost associated with the current turf grass, and could be used as an educational technique or demonstration project for stormwater filtration.

The enclosed conceptual design figures indicate the locations identified for rain garden creation and the associated water bars and drainage swales. Additionally, representative photos of typical rain gardens and conceptual water bars are also included. If you agree with this concept plan for the stormwater reduction project, then please sign below and return a copy to me in the envelope provided. Signing this supports our efforts to obtain additional grant money for design and construction funding. We welcome any suggested changes you might have at this time, so please feel free to write comments on the draft plan and return them to me. Please call me if you have any immediate concerns or questions. Thank you for your consideration.

Please contact me directly should you have any questions pertaining to this project and its scope at (574) 586-3400 or speel@jfnew.com. We are more than happy to address any concerns you might have. Thank you for helping us assist the Crooked Lake Association in their goals to reduce pollutant loading into the Crooked Lake.

Thank you for your consideration.

Sincerely,

Sara Peel
Project Manager

I agree with the above concept plan.

cc. Keith Hoskins, Crooked Lake Association; JFNew file 03-01-10/01

JFNew
Wise Growth Through Stewardship

708 Roosevelt Road
Walkerton, Indiana 46574
Phone: 574-586-3400 ext. 316
Fax: 574-586-3446

Wayne Stanger
Senior Project Manager

Corporate Office:
Walkerton, Indiana

Crete, Illinois

Indianapolis, Indiana

Grand Haven, Michigan

Cincinnati, Ohio

Native Plant Nursery:
Walkerton, Indiana

www.jfnew.com

January 3, 2005

Larry Gilbert
Steuben County Surveyor
317 S. Wayne Street
Angola, Indiana 46703

Dear Mr. Gilbert:

JFNew is working with the Crooked Lake Association (CLA) to complete an engineering feasibility study. The purpose of the project is to address the feasibility of implementing erosion control projects in the Crooked Lake Watershed in order to slow loading of sediment and associated nutrients that can impair water quality in the lake.

As you are aware, one of the concerns that has been identified is the in stream and over the bank erosion within the Palfreyman Drain. Over the bank erosion can be addressed with filter strips and grade stabilization structures to safely lower the runoff into the drain. However, reducing the in stream erosion will be more difficult due to the sandy soils, and volume and velocity of runoff within a watershed where the land use is rapidly changing.

On December 17th we met at your office and discussed the two approaches for addressing the in stream erosion. One approach would be to propose and implement erosion control measures for the most critical areas. As we discussed this would be more of a "Band-Aid" type approach of treating the problem. Once one problem area has been healed another area develops and it turns into a never ending battle.

The second approach would be to complete a design study of the drain and its watershed and implement a project which would address the long-tern concerns and provide a more permanent solution. This approach would take into consideration land use trends in the watershed which significantly affects the volume of runoff. This approach would analysis the drain and make reconstruction recommendations necessary to convey the projected volume of runoff at a velocity required to minimize in stream erosion.

We both agreed addressing the concerns on a long-term and more permanent basis would be a more beneficial approach to all parties involved. Your input would definitely be sought when it comes time to complete the design study. We will recommend to the Crooked Lake Association that they apply for an Indiana Department of

Natural Resources Lake and River enhancement grant to complete a design study

Thank you for helping us assist the Crooked Lake Association in their goals to reduce pollutant loading into Crooked Lake.

Please sign and date below indicating your approval of the design study concept for the Palfreyman Drain. Return in the enclosed stamped envelope.

Signature

1-6-05
Date

Thanks for your cooperation and assistance. If you have any questions give me a call at 574-229-8779.

Wayne Stanger
JFNew

Cc: JFNew file 03-01-10/01

# APPENDIX C:

# CARPENTER DRAIN
# STREAMBANK STABILIZATION PERMIT

# CROOKED LAKE ENGINEERING FEASIBLITY STUDY
# STEUBEN COUNTY, INDIANA

STATE OF INDIANA
DEPARTMENT OF NATURAL RESOURCES

MAILED SEP 0 3 2004

# CERTIFICATE OF APPROVAL
# CONSTRUCTION IN A FLOODWAY

**APPLICATION #** : FW-22926

**STREAM** : Unnamed Tributary Crooked Lake

**APPLICANT** : Crooked Lake Association
Keith Hoskins
801 West Coliseum Boulevard
Fort Wayne, IN 46808-1219

**AGENT** : JF New & Associates, Inc
Joe Exl
708 Roosevelt Road
Walkerton, IN 46574-1220

**AUTHORITY** : IC 14-28-1 with 312 IAC 10

**DESCRIPTION** : Approximately 200' of eroded streambank, along 4 different locations, will be re-graded and stabilized with approximately 100 cubic yards of glacial stone. Soil encapsulated lifts will be placed along the top of the glacial stone wall and will be planted with native grasses and shrubs to provide additional bank stabilization. The new glacial stone wall will have a maximum height of 3' with a 1.5:1 slope. The base of the wall will project streamward approximately 1' beyond the existing bank. Details of the project are contained in information received electronically at the Division of Water on June 9, 2004 and in information received at the Division of Water on June 16, 2004.

**LOCATION** : DOWNSTREAM: The 4-H Fairgrounds; beginning approximately 400' southeast of Crooked Lake and continuing upstream approximately 400' near Angola, Pleasant Township, Steuben County
NE¼, SW¼, NE¼, Section 16, T 37N, R 13E, Angola West Quadrangle
UTM Coordinates: Downstream 4614577 North, 663564 East
UPSTREAM: SW¼, SW¼, NE¼, Section 16, T 37N, R 13E
UTM Coordinates: Upstream 4614508 North, 663671 East

**APPROVED BY** : James J. Hebenstreit

James J. Hebenstreit, P.E., Assistant Director
Division of Water

**APPROVED ON** : September 3, 2004

Attachments: Notice Of Right To Administrative Review
General Conditions
Special Conditions
Service List

**STATE OF INDIANA**
**DEPARTMENT OF NATURAL RESOURCES**

# NOTICE OF RIGHT TO ADMINISTRATIVE REVIEW

## APPLICATION #: FW- 22926

This signed document constitutes the issuance of a permit by the Department of Natural Resources, subject to the conditions and limitations stated on the pages entitled "General Conditions" and "Special Conditions".

The permit or any of the conditions or limitations which it contains may be appealed by applying for administrative review. Such review is governed by the Administrative Orders and Procedures Act, IC 4-21.5, and the Department's rules pertaining to adjudicative proceedings, 312 IAC 3-1.

In order to obtain a review, a written petition must be filed with the Division of Hearings within 18 days of the mailing date of this notice. The petition should be addressed to:

Mr. Stephen L. Lucas, Director
Division of Hearings
Room W272
402 West Washington Street
Indianapolis, Indiana 46204

The petition must contain specific reasons for the appeal and indicate the portion or portions of the permit to which the appeal pertains.

If an appeal is filed, the final agency determination will be made by the Natural Resources Commission following a legal proceeding conducted before an Administrative Law Judge. The Department of Natural Resources will be represented by legal counsel.

# STATE OF INDIANA
# DEPARTMENT OF NATURAL RESOURCES

# GENERAL CONDITIONS

## APPLICATION #: FW- 22926

( 1 ) If any archaeological artifacts or human remains are uncovered during construction, federal law and regulations (16 USC 470, et seq.; 36 CFR 800.11, et al) and State Law (IC 14-21-1) require that work must stop and that the discovery must be reported to the Division of Historic Preservation and Archaeology within 2 business days.

Division of Historic Preservation and Archaeology
Room W274
402 West Washington Street
Indianapolis, IN 46204

Telephone: (317) 232-1646, FAX: (317) 232-8036

( 2 ) This permit must be posted and maintained at the project site until the project is completed.

( 3 ) This permit does not relieve the permittee of the responsibility for obtaining additional permits, approvals, easements, etc. as required by other federal, state, or local regulatory agencies.These agencies include, but are not limited to:

| Agency | Telephone Number |
|---|---|
| *US Army Corps of Engineers, Detroit District | (313) 226-2218 |
| St. Joseph River Basin Commission | (574) 287-1829 |
| Steuben County Drainage Board | (260) 668-1000 |
| Indiana Department of Environmental Management | (317) 233-8488 or (800) 451-6027 |
| Local city or county planning or zoning commission | |

( 4 ) This permit must not be construed as a waiver of any local ordinance or other state or federal law.

( 5 ) This permit does not relieve the permittee of any liability for the effects which the project may have upon the safety of the life or property of others.

( 6 ) This permit may be revoked by the Department of Natural Resources for violation of any condition, limitation or applicable statute or rule.

( 7 ) This permit shall not be assignable or transferable without the prior written approval of the Department of Natural Resources. To initiate a transfer contact:

Mr. Michael W. Neyer, PE, Director
Division of Water
Room W264
402 West Washington Street
Indianapolis, IN 46204

Telephone: (317) 232-4160, Toll Free: (877) 928-3755
FAX: (317) 233-4579

( 8 ) The Department of Natural Resources shall have the right to enter upon the site of the permitted activity for the purpose of inspecting the authorized work.

( 9 ) The receipt and acceptance of this permit by the applicant or authorized agent shall be considered as acceptance of the conditions and limitations stated on the pages entitled "General Conditions" and "Special Conditions".

**STATE OF INDIANA**
**DEPARTMENT OF NATURAL RESOURCES**

# SPECIAL CONDITIONS

## APPLICATION #: FW- 22926

**PERMIT VALIDITY** : This permit is valid for 24 months from the "Approved On" date shown on the first page. If work has not been initiated by September 03, 2006 the permit will become void and a new permit will be required in order to continue work on the project.

This permit becomes effective 18 days after the "MAILED" date shown on the first page. If both a petition for review and a petition for a stay of effectiveness are filed before this permit becomes effective, any part of the permit that is within the scope of the petition for stay is stayed for an additional 15 days.

**CONFORMANCE** : Other than those measures necessary to satisfy the "General Conditions" and "Special Conditions", the project must conform to the information received by the Department of Natural Resources on: June 9, 2004 and June 16, 2004. Any deviation from the information must receive the prior written approval of the Department.

| Number | Special Condition |
|---|---|
| ( 1) | revegetate all bare and disturbed areas with a mixture of grasses (excluding all varieties of tall fescue) and legumes as soon as possible upon completion; low endophyte tall fescue may be used in the ditch bottom and side slopes only |
| ( 2) | appropriately designed measures for controlling erosion and sediment must be implemented to prevent sediment from entering the stream or leaving the construction site; maintain these measures until construction is complete and all disturbed areas are stabilized |
| ( 3) | seed and apply mulch on all disturbed areas not protected by other methods |
| ( 4) | except for the material used as backfill as shown on the above referenced project plans on file at the Division of Water, place all excavated material landward of the floodway * |
| ( 5) | all work must conform with the existing bank at the upstream and downstream limits of the project site |
| ( 6) | do not leave felled trees, brush, or other debris in the floodway * |
| ( 7) | glacial stone placed for bank stabilization must conform to the bank |
| ( 8) | upon completion of the project, remove all construction debris from the floodway * |
| ( 9) | * Note: for regulatory purposes, the floodway is defined as the area inundated by the 100-year frequency flood as shown on Panel 25 of the County of Steuben Flood Insurance Rate Map dated July 3, 1986 |

STATE OF INDIANA
DEPARTMENT OF NATURAL RESOURCES

# SERVICE LIST

## APPLICATION #: FW- 22926

Crooked Lake Association
Keith Hoskins
801 West Coliseum Boulevard
Fort Wayne, IN 46808-1219

JF New & Associates, Inc
Joe Exl
708 Roosevelt Road
Walkerton, IN 46574-1220

*US Army Corps of Engineers, Detroit District
Gary Mannesto
Regulatory Functions Branch
PO Box 1027
Detroit, MI 48231-1027

St. Joseph River Basin Commission
Karen M Mackowiak
227 West Jefferson Boulevard - #1120
South Bend, IN 46601

Steuben County Drainage Board
County Surveyor
County Office Building
317 South Wayne Street, Suite 3K
Angola, IN 46703-1958

*Indiana Department of Natural Resources
North Region Headquarters Dist 2
Division of Law Enforcement
1124 North Mexico Road
Peru, IN 46970

Angola Plan Commission
210 North Public Square
Angola, IN 46703-1960

Steuben County Plan Commission
317 South Wayne Street
Suite 3-L
Angola, IN 46703-1966

Steuben County Soil and Water Conservation District
Peachtree Plaza 200
1220 North 200 West
Angola, IN 46703-9171

Staff Assignment:

| | |
|---|---|
| Administrative | : Stuart L. Peckham |
| Technical | : Stuart L. Peckham |
| Environmental | : Christie L. Kiefer |

# APPENDIX D:

# BIOTIC ASSESSMENT

# CROOKED LAKE ENGINEERING FEASIBLITY STUDY
# STEUBEN COUNTY, INDIANA

**Detailed mIBI results.**

**Table A. Carpenter Drain multi-habitat macroinvertebrate results, June 10, 2004.**

| Class/Order | Family | # | EPT | Tolerance (t) | # x t | % |
|---|---|---|---|---|---|---|
| Bivalvia | Sphaeriidae | 1 | | 8 | 8 | 0.93 |
| Coleoptera | Elmidae | 6 | | 4 | 24 | 5.56 |
| Diptera | Chironomidae | 21 | | 6 | 126 | 19.44 |
| Diptera | Chironomidae (blood red) | 1 | | 8 | 8 | 0.93 |
| Diptera | Ephydridae | 1 | | 6 | 6 | 0.93 |
| Diptera | Simuliidae | 5 | | 6 | 30 | 4.63 |
| Ephemeroptera | Baetidae | 2 | 2 | 4 | 8 | 1.85 |
| Gastropoda | Physidae | 1 | | 8 | 8 | 0.93 |
| Trichoptera | Hydropsychidae | 63 | 63 | 4 | 252 | 58.33 |
| Platyhelmenthes | Turbellaria | 1 | | 4 | 4 | 0.93 |
| Platyhelmenthes | Hirudenia | 1 | | | | 0.93 |
| Arthropoda | Asellidae | 1 | | 8 | 8 | 0.93 |
| Arthropoda | Asticidae | 1 | | 6 | 6 | 0.93 |
| Arthropoda | Talitridae | 3 | | 8 | 24 | 2.78 |
| | | **108** | **65** | | **4.7** | |
| | | | | | **HBI** | |

**Table B. Carpenter Drain mIBI metrics, June 10, 2004.**

| **Metric** | | **Metric Score** |
|---|---|---|
| HBI | 4.74 | 4 |
| Number of Taxa (family) | 14 | 4 |
| Number of Individuals | 108 | 2 |
| % Dominant Taxa | 58.3 | 2 |
| EPT Index | 3 | 2 |
| EPT Count | 65 | 4 |
| EPT Count/Total Count | 0.60 | 6 |
| EPT Abundance./Chironomid Abundance | 2.95 | 4 |
| Number of Individuals per Square | 3.48 | 0 |
| Chironomid Count | 22.00 | 4 |
| **mIBI Score** | | 3.20 |

**Table C. Palfreyman Drain multi-habitat macroinvertebrate results, June 10, 2004.**

| Class/Order | Family | # | EPT | Tolerance (t) | # x t | % |
|---|---|---|---|---|---|---|
| Bivalvia | Sphaeriidae | 3 | | 8 | 24 | 2.97 |
| Coleoptera | Elmidae | 50 | | 4 | 200 | 49.50 |
| Diptera | Chironomidae | 12 | | 6 | 72 | 11.88 |
| Diptera | Chironomidae (blood red) | 9 | | 8 | 72 | 8.91 |
| Diptera | Simuliidae | 1 | | 6 | 6 | 0.99 |
| Ephemeroptera | Baetidae | 3 | 3 | 4 | 12 | 2.97 |
| Platyhelmenthes | Annelida | 5 | | | | 4.95 |
| Trichoptera | Hydropsychidae | 16 | 16 | 4 | 64 | 15.84 |
| Trichoptera | Hydroptilidae | 1 | 1 | 4 | 4 | 0.99 |
| Arthropoda | Talitridae | 1 | | 8 | 8 | 0.99 |
| | | **101** | **20** | | **4.6** | |
| | | | | | **HBI** | |

**Table D. Palfreyman Drain mIBI metrics, June 10, 2004.**

| Metric | | Metric Score |
|---|---|---|
| HBI | 4.57 | 4 |
| Number of Taxa (family) | 10 | 2 |
| Number of Individuals | 101 | 2 |
| % Dominant Taxa | 49.5 | 2 |
| EPT Index | 4 | 4 |
| EPT Count | 20 | 2 |
| EPT Count/Total Count | 0.20 | 2 |
| EPT Abundance./Chironomid Abundance | 0.95 | 2 |
| Number of Individuals per Square | 4.04 | 0 |
| Chironomid Count | 21.00 | 4 |
| **mIBI Score** | | 2.4 |

**STREAM:** Palfreyman Drain **RIVER MILE:** _____ **DATE:** 6/10/2004 **QHEI SCORE** 39

**1) SUBSTRATE: (Check ONLY Two Substrate Type Boxes: Check all types present)** **SUBSTRATE SCORE** 12.5

| TYPE | POOL | RIFFLE | | | POOL | RIFFLE |
|---|---|---|---|---|---|---|
| [ ] [ ] BLDER/SLAB(10) | | | [ ] [X] GRAVEL(7) | | X | X |
| [ ] [ ] BOULDER(9) | | | [X] [ ] SAND(6) | | X | X |
| [ ] [ ] COBBLE(8) | X | X | [ ] [ ] BEDROCK(5) | | | |
| [ ] [ ] HARDPAN(4) | | | [ ] [ ] DETRITUS(3) | | | |
| [ ] [ ] MUCK/SILT(2) | | | [ ] [ ] ARTIFIC(0) | | | |

TOTAL NUMBER OF SUBSTRATE TYPES: [ ] >4(2) [X] <4(0)

| SUBSTRATE ORIGIN (all) | | SILT COVER (one) | |
|---|---|---|---|
| [ ] LIMESTONE(1) | [ ] RIP/RAP(0) | [ ] SILT-HEAVY(-2) | [X] SILT-MOD(-1) |
| [X] TILLS(1) | [ ] HARDPAN(0) | [ ] SILT-NORM(0) | [ ] SILT-FREE(1) |
| [ ] SANDSTONE(0) | | Extent of Embeddedness (check one) | |
| [ ] SHALE(-1) | | [ ] EXTENSIVE(-2) | [ ] MODERATE(-1) |
| [ ] COAL FINES(-2) | | [X] LOW(0) | [ ] NONE(1) |

NOTE: (Ignore sludge that originates from point sources: score is based on natural substrates)

COMMENTS: _____

**2) INSTREAM COVER:** **COVER SCORE** 5

TYPE (Check all that apply)

- [ ] UNDERCUT BANKS(1)
- [X] OVERHANGING VEGETATION(1)
- [ ] SHALLOWS (IN SLOW WATER)(1)
- [ ] DEEP POOLS(2)
- [ ] ROOTWADS(1)
- [ ] BOULDERS(1)
- [ ] OXBOWS(1)
- [X] AQUATIC MACROPHYTES(1)
- [ ] LOGS OR WOODY DEBRIS(1)

AMOUNT (Check only one or Check 2 and AVERAGE)

- [ ] EXTENSIVE >75%(11)
- [ ] MODERATE 25-75%(7)
- [X] SPARSE 5-25%(3)
- [ ] NEARLY ABSENT <5%(1)

COMMENTS: _____

**3) CHANNEL MORPHOLOGY: (Check ONLY ONE per Category or Check 2 and AVERAGE)** **CHANNEL SCORE** 6.5

| SINUOSITY | DEVELOPMENT | CHANNELIZATION | STABILITY | MODIFICATION/OTHER | |
|---|---|---|---|---|---|
| [ ] HIGH(4) | [ ] EXCELLENT(7) | [ ] NONE(6) | [X] HIGH(3) | [ ] SNAGGING | [ ] IMPOUND |
| [ ] MODERATE(3) | [ ] GOOD(5) | [ ] RECOVERED(4) | [ ] MODERATE(2) | [ ] RELOCATION | [ ] ISLAND |
| [X] LOW(2) | [ ] FAIR(3) | [ ] RECOVERING(3) | [ ] LOW(1) | [X] CANOPY REMOVAL | [ ] LEVEED |
| [X] NONE(1) | [X] POOR(1) | [X] RECENT OR NO RECOVERY(1) | | [ ] DREDGING | [X] BANK SHAPING |
| | | | | [ ] ONE SIDE CHANNEL MODIFICATION | |

COMMENTS: _____

**4) RIPARIAN ZONE AND BANK EROSION: (Check ONE box or Check 2 and AVERAGE per bank)** **RIPARIAN SCORE** 3.5

River Right Looking Downstream

| RIPARIAN WIDTH (per bank) | | EROSION/RUNOFF-FLOODPLAIN QUALITY | | | BANK EROSION | |
|---|---|---|---|---|---|---|
| L | R (per bank) | L | R (most predominant per bank) | L R (per bank) | L | R (per bank) |
| [ ] | [ ] WIDE >150 ft.(4) | [ ] | [ ] FOREST, SWAMP(3) | [X] [X] URBAN OR INDUSTRIAL(0) | [ ] | [X] NONE OR LITTLE(3) |
| [ ] | [ ] MODERATE 30-150 ft.(3) | [ ] | [ ] OPEN PASTURE/ROW CROP(0) | [ ] [ ] SHRUB OR OLD FIELD(2) | [X] | [ ] MODERATE(2) |
| [ ] | [ ] NARROW 15-30 ft.(2) | [ ] | [ ] RESID.,PARK,NEW FIELD(1) | [ ] [ ] CONSERV. TILLAGE(1) | [ ] | [ ] HEAVY OR SEVERE(1) |
| [X] | [X] VERY NARROW 3-15 ft.(1) | [ ] | [ ] FENCED PASTURE(1) | [ ] [ ] MINING/CONSTRUCTION(0) | | |
| [ ] | [ ] NONE(0) | | | | | |

COMMENTS: _____

**5) POOL/GLIDE AND RIFFLE/RUN QUALITY** **NO POOL = 0** **POOL SCORE** 0

MAX.DEPTH (Check 1)

- [ ] >4 ft.(6)
- [ ] 2.4-4 ft.(4)
- [ ] 1.2-2.4 ft.(2)
- [ ] <1.2 ft.(1)
- [X] <0.6 ft.(Pool=0)(0)

MORPHOLOGY (Check 1)

- [ ] POOL WIDTH>RIFFLE WIDTH(2)
- [ ] POOL WIDTH=RIFFLE WIDTH(1)
- [ ] POOL WIDTH<RIFFLE WIDTH(0)

POOL/RUN/RIFFLE CURRENT VELOCITY (Check all that Apply)

- [ ] TORRENTIAL(-1)
- [ ] FAST(1)
- [ ] MODERATE(1)
- [ ] SLOW(1)
- [ ] EDDIES(1)
- [ ] INTERSTITIAL(-1)
- [ ] INTERMITTENT(-2)

COMMENTS: _____

**RIFFLE SCORE** 1

| RIFFLE/RUN DEPTH | RIFFLE/RUN SUBSTRATE | RIFFLE/RUN EMBEDDEDNESS | |
|---|---|---|---|
| [ ] GENERALLY >4 in. MAX.>20 in.(4) | [ ] STABLE (e.g., Cobble,Boulder)(2) | [ ] EXTENSIVE(-1) | [ ] NONE(2) |
| [ ] GENERALLY >4 in. MAX.<20 in.(3) | [ ] MOD.STABLE (e.g., Pea Gravel)(1) | [X] MODERATE(0) | [ ] NO RIFFLE(0) |
| [X] GENERALLY 2-4 in.(1) | [X] UNSTABLE (Gravel, Sand)(0) | [ ] LOW(1) | |
| [ ] GENERALLY <2 in.(Riffle=0)(0) | [ ] NO RIFFLE(0) | | |

COMMENTS: _____

**6) GRADIENT (FEET/MILE):** 23.6 **% POOL** 5 **% RIFFLE** 5 **% RUN** 90 **GRADIENT SCORE** 10